THE B. C. BRIDGE.

THE BLAIR CROSSING BRIDGE.

A REPORT

To MARVIN HUGHITT, President of the Missouri Valley and Blair Railway and Bridge Company,

BY

GEORGE S. MORISON, Chief Engineer.

SUBJECTS.

APPENDICES.

PLATES.

1886.

New York, May 1, 1886.

Marvin Hughitt, Esq.,

President Missouri Valley and Blair Railway and Bridge Co.

Dear Sir:—

I submit the following final report in relation to the construction of your bridge across the Missouri River.

Yours truly,

GEO. S. MORISON,

Chief Engineer.

THE BLAIR CROSSING BRIDGE.

I.

PRELIMINARY NARRATIVE.

On November 17th, 1881, at the request of Mr. Horace Williams, of the Executive Committee of the Sioux City and Pacific Railroad, I met a number of gentlemen connected with the direction and management of that railroad, at Missouri Valley, with reference to the construction of a bridge to connect the Iowa portion of that railroad with its lines in Nebraska. On the same day I visited the river at the Blair crossing with Mr. J. E. Ainsworth, Chief Engineer of the Sioux City and Pacific Railroad, and, with the aid of one of the transfer boats, examined it hastily for some miles above the transfer then in operation. As the situation appeared to be a very bad one for a crossing, it was suggested that the Decatur location be examined also; and with Mr. Ainsworth I visited Decatur on the following day. I arranged then to have a series of borings made at both points, and such surveys as were necessary.

I again visited both places about the end of January. Five borings had then been made at Blair Crossing, which had established the fact that good rock bottom existed at a much less depth than had been feared. No borings had then been completed at Decatur.

On the 10th of February, I made a report to Mr. Horace Williams, which was intended to cover the general questions of a bridge at Blair Crossing. In this report I recommended the construction of a high bridge, and selected a location which was about 1,400 feet down-stream from where the borings had been made; the report was accompanied with estimates and comparisons of different structures.

After my second visit there, borings were made at Decatur, and the tools were brought back to Blair Crossing and additional borings made there. The result of the borings at Decatur showed an exceptionally bad bottom, and made it inexpedient to consider the project of building a bridge there. The additional borings made at Blair Crossing showed the rock to be some feet deeper at the point I had selected for a bridge crossing than at that at which the original borings had been made. On the 26th of April, 1882, I made a second report to Mr. Williams, in which I recommended that the bridge be located 500 feet up-stream from the original location, and the dike 300 feet up-stream from the original location. This was the final location on which the bridge was built: I have since regretted that the original location was not adhered to.

The scheme embraced in my reports involved a large amount of shore protection on both sides of the river. This was begun in the spring of 1882, under the immediate charge of Mr. John McKeen, who worked under the direction of Mr. Ainsworth. On June 12th, 1882, Mr. H. W. Parkhurst, as Assistant Engineer, was placed in charge of this work.

On the 27th day of June, 1882, the Act of Congress authorizing the construction of a bridge at this point was approved. On the 1st day of July, 1882, I submitted a plan of the proposed bridge to the Secretary of War. On the 1st day of August, 1882, I was advised by General Wright, Chief of Engineers, U. S. Army, that the plans had been approved by the Secretary of War.

It was thought best that the Bridge Company should put in the foundations itself; and this work was done by the company's men, under the direction of Mr. H. W. Parkhurst, First Assistant Engineer. On September 28th, 1882, a contract was closed with the firm of T. Saulpaugh and Company, for the construction of the four principal piers. On December 2d, 1882, a contract was made with the Keystone Bridge Company for the construction and erection of the superstructure. Contracts were also made for grading the east and the west approach to the bridge (not including the steam-shovel work), and this work was finished during the season of 1882.

The work was fairly started in September, 1882, and carried forward without interruption till November, 1883, when the bridge was opened for traffic. The breaking up of the ice in March, 1884, was unusually violent; the loose ice, being carried over the dike, struck the trestle-work of the east approach, and carried away 1,600 feet of it. Traffic across the bridge was interrupted from March 23d to May 18th; the repairs of the trestle were then completed, and the bridge has been in regular use since that time.

II.

GENERAL DESCRIPTION.

The Missouri Valley and Blair Railway and Bridge Company owns $3\frac{86}{100}$ miles of railroad, from the connection with the main line of the Sioux City and Pacific Railroad on the east side of the Missouri, to its connection with the same line on the west side of the Missouri. The features of this line are shown on Plate 3.

The situation of this bridge differs from that of any of the other bridges across the Missouri, in that the river does not touch the bluff on either side for many miles above and below the location of the bridge. The nearest point below the bridge at which the river now strikes the bluff is on the west side, a little above Florence, and 18 miles below the bridge line. Above the bridge, the nearest point at which it strikes the bluff is Decatur, 50 miles away. The fact that the Missouri runs for so great a distance here without striking the bluff makes its regimen unusually irregular, there being no positive fixed points to exercise a corrective influence. This irregularity was further complicated by the fact that a cut-off occurred within a short distance of the bridge site in 1881, and the river had not wholly recovered from the effects of this cut-off when the bridge was begun. In fact, the uncertainties and difficulties of this location were so great, that it was considered expedient, when the preliminary examinations were made, to make an examination also at Decatur; but the bad character of the bottom at the last-named point (rock not being found at any reasonable depth), combined with commercial considerations, fixed the neighborhood of the old Blair crossing of the Sioux City and Pacific Railroad as the proper place for a bridge.

At the time the work was begun the river was of quite indefinite width, and was rapidly encroaching on the bottom land on the west side, while the large sand-bar on the east side was divided by a secondary or slough channel, through which there was a strong current in high water. The borings, made at a point which seemed about as convenient as any for the crossing, showed bed-rock at an unexpectedly convenient height, and indicated that, while the control of the river might be unusually difficult, the construction and maintenance of the bridge itself would be a comparatively simple thing.

It was therefore determined to build a bridge of such character as could be depended on to pass the whole discharge of the Missouri River, without reference to the former width of the river; this bridge to be of a character which would give the least trouble if the channel and direction of the current were irregular in their action, and then by artificial means to confine the river to a reasonably fixed course.

The plan adopted for the bridge provided for a bridge across the river 1,000 feet long, and of a height that would give a clear head-room of 50 feet between the lower chord and high water. High water was determined, not from any particular flood, but by a careful comparison with other bridges which are intended to give the same head-room: the heights of a long series of flood waves at the Blair crossing were compared with the heights of the corresponding flood waves at Plattsmouth, and the clear height above these flood waves was made as nearly as possible the same as the clear height above the corresponding flood waves at the Plattsmouth bridge. That the width of 1,000 feet is enough to pass the Missouri is shown by the fact that, at a number of points below this bridge, where the channel has been constant for a long series of years, the river has itself reduced its width to less than a thousand feet, by raising the bottom land to the high-water level. All of these narrow points occur at places where the river runs along a bluff, and generally where the bed-rock is not as deep as at the Blair Crossing bridge. The high-water width, selected by the Government engineers as that most consistent with stability on this section of the river, is but a trifle more than 800 feet.

The main bridge was divided into three equal spans, each 330 feet long between centers of end pins, this length being the most economical division of spans. The distance between the centers of the end piers is 999 feet. At each end of the bridge is a short approach span designed to reach over the embankment.

The east approach ascends from the level of the track on the bottom land, with a 1 per cent. grade (52.8 feet per mile) to the level of the track on the bridge. This entire approach is now a solid earth embankment. 3,000 feet of it were originally built in the form of a timber trestle. The west approach is also built as a solid earth embankment, excepting for 1,184 feet, including the crossings of the old Sioux City and Pacific Railroad and of Fish Creek, where a wooden trestle is built with a short Howe truss over the railroad. There is a slight descent from the bridge to Fish Creek, but the Blair station is 30 feet higher than the track on the bridge.

To render the regimen of the river stable at this point, the west bank has been protected by a revetment of brush and stone, this protection above the bridge following a line carefully fixed before the work was begun. A point was selected about two miles above the bridge, on the east bank, as a governing point for controlling the east shore line, and a revetment of brush and stone, commonly known as the upper protection, was put in here in the summer of 1882. A dike was built across the sand-bar, about 600 feet above the bridge, and making an angle of 5° with the axis of the bridge. This dike closed the slough channel, and confined the river to the space between the end of the dike and the protected west bank. The slough channel is also closed by the solid embankment of the railroad across it.

The direction of the axis of the bridge is east and west. The direction of the dike is 5° north of east. The first location of the bridge line was 500 feet south of the line on which the bridge was built, the original location of the dike being 300 feet south of the location on which it was built; the change was made because the preliminary borings showed the rock to be four or five feet deeper at the point of the first location than at that finally adopted. Between the protected shore line on the west side of the river and the bluffs, which are about 3,000 feet off, is a high prairie bottom, which was partly submerged in the great flood of 1881. Fish Creek, a small stream which comes from the north, runs through this bottom land, and a careful examination of the surface of this bottom land shows a slight depression, which evidently marks an ancient channel of the Missouri River, which has long since silted up to the level of the bottom land. The embankment of the west approach crosses this old channel, which proved to contain below the surface a mass of mud too soft to support the heavy embankment of the approach; the embankment settled fully 40 feet, forcing up the ground on each side. This added greatly to the cost of the bridge, and finally made it necessary to change the west approach span for a longer one. The line of the original location would have crossed this same slough, but at a greater distance from the bridge and at a better angle, so that practically the amount saved in the foundations was more than made up for by the increased cost of the west approach.

At the time of the beginning of the work, an attempt was made to get a tide-level datum, and all levels were referred to this datum, and are so stated in this Report. Subsequently this datum was checked with some of the benches established by the Government engineers on the survey of the Missouri River, and was found to be 19.52 feet lower than the true datum established by the Government.

III.

RECTIFICATION WORKS.

The rectification works may be divided into three distinct parts: first, the Shore Protection on the east side; second, the Dike, also on the east side; and third, the West Shore Protection.

The East Shore Protection was designed to fix a point on the east bank of the river beyond which the channel should not be allowed to encroach, and from which the main channel would shoot in a nearly direct course till it struck the upper end of the protection on the west shore. The Dike was intended to close all secondary channels which might exist in a river of the abnormally great width which existed at high water at the location selected. The West Protection was simply intended to hold the west bank, and convert the friable bottom land into the equivalent of a permanent bluff shore.

These works have accomplished their purposes with entire satisfaction, though at greater expense than was originally estimated, except in one respect. During the high-water season the channel of the river runs in an approximately direct course from the upper East Protection work to the head of the West Protection; but during the low-water season the channel becomes so narrow that a much more crooked course is possible than with the greater width of the high-water river. The result is that a series of bends is formed between the upper protection and the end of the dike, which have cut into the bar above the dike, and at times put the main channel of the river immediately along the western part of the dike. This difference in the course of the Missouri at high and low water is a striking fact, which must not be overlooked in a study of the river. The low-water width is often less than one third the high-water width, and the curves which the channel can easily take have a correspondingly less radius at low than at high water. During the high-water season a channel and a series of shoals are formed which correspond to the dimensions of the river at that time. When the river falls the sand-bars are left dry, but the channel begins to form a series of small bends corresponding to its reduced width. As during high water the river has

eroded the bottom land on the outside of the larger bends, so during low water it erodes the sand-bars on the outside of the small bends which the low-water channel has formed. With the next flood these distinctive marks of the low river are obliterated, but a similar action occurs again with the next low-water season. As the Missouri at low water is a comparatively small river and the channel not very deep, this peculiar action of the low-water channel can be guarded against, and, if watched, is not a source of special danger; but it must not be overlooked in any plan which contemplates securing a direct channel. There are places on the river where the corrective action of bluffs makes the channel nearly the same at high and at low water, but generally, and especially in a place like that at Blair Crossing, the direction of the current at low water is liable to vary nearly 45° from the high-water direction. During the construction of the bridge, the current was nearly always at right angles to it, and parallel to the protected west shore. At high water the river generally struck the west protection quite a distance above the dike, and made a direct course through the bridge; at low water it has swept across from the end of the dike to strike the west bank only a little above the bridge, and in November, 1885, the angle of the current at Pier III. was about 45° with the axis of the bridge.

The place selected to begin the protection of the east shore was at the upper one of the old transfer landings, the piles driven for this landing serving as a base to begin work upon. This will be seen on the map on Plate 2. At the time the work was begun, the full force of the current impinged against the bank at this point. An arbitrary line was selected, and it was determined to stop the cutting of the bank when the river reached this line. The protection was made by dumping in stone and brush, the brush being laid in a cradle with small stone on the inside and the whole wired together, and dumped by tipping the cradle. The work was carried on during the summer of 1882 with bundles of this kind, and the mass of bundles then put in was subsequently topped out with a large quantity of heavy riprap stone. As the protection work settled it was reinforced from above until it became practically stable. The whole length of the bank protected here is now 1,000 feet. For the last two or three years the current has seldom been along this protection; but whenever it again strikes the eastern part of it with full force, the protection must be extended farther eastward, and may require some additional strengthening elsewhere.

The river subsequently cut into the bank somewhat below this protection and near the second transfer landing, which is about half a mile below the one used as the base of the upper protection. This cutting has at no time been very violent, and has been checked by the use of bundles.

There have been used in the east shore protection 6,033 cords of brush and 36,122 tons of stone.

The initial point of the dike was fixed 600 feet above the bridge line, and on the line of Pier I. From this the dike extended eastward, making an angle of 5° with the bridge line. It was built approximately at right angles to the stream, so that in general the current would only strike the end of the dike, but was inclined slightly, so that a current striking it would be deflected towards the end of the dike rather than in the opposite direction.

The westerly portion of the dike for a distance of 500 feet from the initial point was made in the form of a willow mattress loaded with stone; it was turned around the initial point, and given a return down-stream. The total width of the mattress was 150 feet, of which 50 feet were below and inside the center line of the dike, and 100 feet above and outside. The brush-work was built by laying strands of brush on the bar 5 feet apart, these strands consisting of brush laid lengthwise, and strengthened by having a line of twisted wire in the centre. Stakes were then driven at regular intervals of 5 feet on the edge of the strands, these stakes carrying wires which were secured around the strands. Four courses of brush were then laid over the strands, and a second set of strands laid on at right angles to the first. The wires attached to the stakes were then bound to the upper strands and the stakes withdrawn. The brush was then covered with sand to give weight and protect from fire, and loaded with rock. The same process was then repeated to form a narrower mattress on the top, until the work was brought to the desired level. This method of construction is one which is not recommended for work of this class. To prevent the water racing along the side of the dike, five spurs 300 feet long and 50 feet wide were built along the north side, their construction being similar to that of the dike itself. The portion of the dike east of the mattress-work was built in the form of an earth embankment, the slopes of which were protected with brush and stone. The chief trouble experienced was in the crossing of an old slough channel (about 2,000 feet east of the east end of the bridge); a pile bridge was built across this slough, and this bridge was subsequently filled with brush and stone and covered with earth. The dike as originally built was finished at an elevation of 1019, which was above any ordinary high-water level, and a track was laid the whole length of it. In the spring of 1884, the ice went out with an abnormally high river, and, passing over the top of the dike, struck the trestle below and knocked it down, while the earthen portion of the dike was nearly obliterated. Two weeks later, this flood was followed by another flood of about the same height, which also swept over the sand-bar and the damaged dike. When the water receded it was found that the rectification works had been perfectly successful so far as they had been adequate; the slough channel, which had given trouble heretofore, had entirely disappeared, and a smooth, unbroken sand-bar extended to the east end of the bridge. It was determined, however, to repair the dike in a much more substantial manner than it had originally been built. A woven mattress, 100 feet wide, 90 feet on the outside of the center line of the dike, and 10 feet on the inside, was built, extending from the high sand-bar on the east along the course of the dike, curving southward with a radius of 300 feet, to connect with a north and south line, and thence following this north and south line across the bridge line immediately east of Pier I. This woven mat was made entirely of willow, without wire, excepting the selvage edge, the willow being woven in together in a manner similar to that used by the United States Government in its protection works. This mat finished about a foot thick; a gang of men would weave nearly 100 feet in a day; for efficiency and economy of construction it is believed to be the best method of construction yet devised for mattress revetment work. The woven mat was covered with stone, and the track laid on a stone embankment, which embankment was gradually raised to the level of 1023, which is above the great flood of 1881. Since its completion in this manner, the current has struck the dike at several points, and caused some settlement, the mattress on the up-stream side having settled until it is now generally under water or buried in sand. Some slight repairs have been required, but the work is standing very well.

There have been used in the dike 9,300 cords of brush and 47,947 tons of stone.

The west shore protection was really begun in the spring of 1883, though a little work had been done there previously. As the course of the current through the bridge would depend largely on the form of this shore, a line was selected on which the caving shore should be held. A trench was then excavated along the outside of this adopted shore line, this trench being 32 feet wide on top, the sides given a slope of 1½ hori-

zontal to 1 vertical next to the shore, and ½ horizontal to 1 vertical next to the river, and the excavation carried as deep as the stage of high water would permit; it was then filled with heavy riprap stone. When the river cut into the line of this trench, the stones dumped themselves into the water and formed a base for additional protection. The protection was then reinforced by putting in additional stone, and by brush bundles similar to those used on the east side.

The west bottom land is what is known as a gumbo bottom, there being a layer of gumbo twenty feet or more in thickness above the friable sands, which are readily washed by the water. This character of bottom land, not unusual on the Missouri, does not wear away uniformly, but the gumbo holds up until a large area of sand has been washed from below, when a piece of land perhaps 50 feet wide and 200 or 300 feet long will settle down at once. This occurred on several occasions as the protection work proceeded, there being a very large settlement about 1,000 feet above the bridge; after the first settlement, however, comparatively little change took place at this large sink, and the shore line has been maintained without difficulty. The west protection required constant watching during the seasons of 1882 and 1883; during 1884 it required less attention, and in 1885 comparatively little. Repairs have generally been made with brush bundles and stone, but at the upper and lower ends considerable stretches of woven mat have also been used. The lower mat has slid into the river, and its operation is not wholly satisfactory. The upper mat was built in advance of the cutting of the river, and much of it lost its strength before it was submerged, so that it became useless. This west protection will require a little attention for some years, but until the river strikes the upper portion of it, which is desirable for various reasons, the repairs will be comparatively light. Whenever the river does strike the upper portion of this protection with full force, a considerable settlement will undoubtedly occur, which will have to be repaired in the same way as other repairs have hitherto been made.

There have been used in the west protection 14,221 cords of brush and 79,350 tons of stone.

The cost of the protection works at the Blair Crossing bridge has been exceptionally high. This has been due in part to the great cost of stone, there being no stone anywhere in the neighborhood of the bridge. A portion of the stone used was brought from the quarries on the Platte River, near Louisville; a small portion was brought from the quarries at Sioux Falls, Dakota, but the largest amount came from the Le Grand quarries in eastern Iowa. The tabular statement of cost, given hereafter, shows how large a portion of the entire cost of the protection work was paid for the transportation of stone.

Another element which made the protection work expensive was the fact that it was felt that it must be done in the most thorough manner, and that mattress protection, such as may be used safely where the only object is to regulate the course of the river, but which is liable to injury and temporary destruction, was not sufficiently permanent in its character to trust to hold the bank of a river where the preservation of a bridge depended on holding this bank in exactly the right place. The experience acquired on this work was very valuable, and undoubtedly it could be done again for a somewhat less sum.

IV.

SUBSTRUCTURE.

The four piers are founded on pneumatic caissons 54 feet long, 24 feet wide, and 17 feet high over all, which were sunk to the rock by the plenum-pneumatic process. The foundations were put in by the company's men under the direction of the engineers. The contract for the masonry was awarded to the firm of T. Saulpaugh & Co.

The caissons for Piers I. and II. were built on the dry sand-bar on the east side of the river. The caisson for Pier III. was built in position on pile false work, and lowered by long screws to the bottom of the river. The caisson for Pier IV. was built in position in a pit excavated to the surface of the water.

The pneumatic machinery was set up on the east side of the river, immediately east of Pier II. It consisted of two No. 4 Clayton duplex compressors, and two No. 10 Cameron pumps to work the Eads sand pump excavators, with the necessary pipe fittings, etc., the power being supplied by three 60 H. P. portable boilers. A temporary pile bridge was built across the narrow winter channel, which was made a double-track bridge from the east sand-bar to Pier III. The north track of this bridge was used as a transfer track for the general business of the Sioux City and Pacific Railroad; the south track, to take material to Pier III. The Cameron pumps were placed on this pile bridge far enough west to have deep water to pump from. The position of the machinery was not changed till the completion of Pier III., the air and water being led to the different foundations in pipes. On the completion of Pier III. the entire machinery was moved to the west side of the river, and set up there for use in sinking the foundation of Pier IV.

The caissons used for the four piers were precisely similar. They were built of white-pine timber, bolted together at all points of intersection, and filled with Portland cement concrete. The outer planking of Caissons II. and III. is of oak; all the planking of Caissons I. and IV. is of pine. The masonry of Piers II. and III. rests on top of the caisson, 17 feet above the cutting edge. The masonry of Piers I. and IV. is started 20 feet above the top of the caissons, the intervening space being occupied by a crib-work filled with Portland cement concrete. The form of construction adopted for Piers I. and IV. was slightly cheaper than that for Piers II. and III., but it was thought desirable to carry the model form of the pier as low as possible in Piers II. and III. so as to form a minimum obstruction to the passage of the water. The slight disturbance which the piers as built offer to the current, is appreciated by any one who tries to row up to one of these piers from below.

The framing of the caisson for Pier II. was begun October 12th, (Caisson I. being left uncompleted); the caisson for Pier II., including the concrete filling above the working chamber, was finished November 20th; air pressure was put on November 22d, the laying of masonry began November 23d, and the caisson reached the bed-rock, at elevation 955, December 15th. The work of filling the working chamber with concrete was begun December 18th, and completed December 21st. The masonry of Pier II. was finished January 29th.

The construction of the staging for Pier III. was begun December 2d. The caisson itself was begun December 5th. The lowering of the caisson with screws began January 8th. Air pressure was put on January 10th, and on the 12th of January the caisson rested on the bottom of the river, and the concrete filling above the working chamber was completed. The laying of masonry began January 13th, and the caisson reached the rock at elevation 951.1, February 12th. The concrete filling of the working chamber was begun February 12th, and finished February 15th. The masonry of this pier was completed March 3d.

Work on the foundation of Pier I. was made subservient to that on Piers II. and III., and conducted with some irregularity. The framing of the caisson was begun September 19th, but the caisson was not fin-

ished till December 21st; air pressure was put on December 29th, and the caisson was sunk to elevation 985.1 by January 6th, when work was suspended and the pressure let off. The concrete filling of the crib was completed on January 18th, and the laying of masonry began on February 7th; air pressure was put on and sinking resumed on February 16th, and on March 2d the caisson reached the rock at elevation 957.5. The work of filling the working chamber was completed March 5th, and the masonry was completed March 31st.

On March 6th, 7th, and 8th, the machinery was transferred from the east side of the river to the west side, there being barely time to get it across before the loss of the winter bridge, which occurred on March 9th.

The framing of the caisson for Pier IV. was begun January 23d, and the erection of the caisson in the pit excavated for the purpose was begun February 8th. This caisson was completed, including the concrete filling above the working chamber, March 14th; air pressure was put on March 17th; the crib-work and concrete filling were finished April 2d; masonry was begun April 5th; the caisson reached the rock, at elevation 954.9, April 14th; the concrete filling of the working chamber was begun April 17th, and finished April 19th. The masonry of this pier was completed May 9th.

The full details of the four piers, of the caissons, the air-locks, and the appliances used in connection therewith, are given on Plates 4, 5, 6, 7, and 9. The rate of progress in sinking is illustrated graphically on Plate 8. Full records of the progress in detail of sinking these foundations were kept, and these records are given in Appendix E. The detail cost is given in Appendix F.

The concrete used was manufactured in a mixer consisting of a 9-inch spiral conveyer shaft running in a wrought-iron trough. Sand and cement were mixed by this mixer, and stone was thrown in after depositing the concrete mortar in position, the stones being thrown in separately by hand. The proportions used were generally as follows: three of sand to one of cement in the caisson above the working chamber; four of sand to one of cement in the working chamber and in the crib-work; rough stone of irregular size was worked into this concrete mortar, excepting in the filling of the working chamber, which was entirely of concrete. Moreover, the working chamber was first made tight around the edges, and for about a foot over the whole bottom, with a mixture of two of sand to one of cement.

The stone used for masonry was quarried at Mankato, Minn.; it is an excellent limestone of yellow color, which has shown evidences of durability in various structures around Mankato. The cut-waters of Piers I. and II. were made of blue granite quarried near St. Cloud, Minn. The faced stones are laid in Portland cement mortar, and the backing in Milwaukee cement, excepting that in very cold weather Portland cement was used throughout.

A table showing the amount of cement used is given in Appendix D.

The specifications for masonry are given in Appendix B.

The total cost of the four piers in detail was as follows: —

	Cost, excluding Freight.		Freight Charges.		Cost, including Freight.	
FOUNDATION I.						
Caisson and filling . .	$9,596.51		$2,157.00		$11,753.51	
Crib and filling	5,594.38		1,773.78		7,368.16	
Air-lock, shafts, etc. .	1,420.51		61.09		1,481.60	
Sinking caisson	5,004.01		4.80		5,008.81	
Erection and removal of machinery	739.85		23.86		763.71	
		$22,355.26		$4,020.53		$26,375.79
FOUNDATION II.						
Caisson and filling . .	10,256.22		2,130.34		12,386.56	
Air-lock, shafts, etc. .	1,522.54		44.88		1,567.42	
Sinking caisson	4,989.17		.30		4,989.47	
Erection and removal of machinery	616.04		23.86		639.90	
		17,383.97		2,199.38		19,583.35
FOUNDATION III.						
Caisson and filling . .	11,489.65		2,329.69		13,819.34	
Air-lock, shafts, etc. .	1,491.85		44.95		1,536.80	
Sinking caisson	6,174.12		.30		6,174.42	
Erection and removal of machinery	689.88		23.86		713.74	
		19,845.50		2,398.80		22,244.30
FOUNDATION IV.						
Caisson and filling . .	9,236.06		2,016.39		11,252.45	
Crib and filling	4,762.22		1,541.24		6,303.46	
Air-lock, shafts, etc. .	1,477.91		43.17		1,521.08	
Sinking caisson	6,104.55		.28		6,104.83	
Erection and removal of machinery	822.81		156.62		979.43	
		22,403.55		3,757.70		26,161.25
TOTAL OF FOUNDATIONS		$81,988.28		$12,376.41		$94,364.69
Masonry, Pier I. . .		20,938.72		4,581.05		25,519.77
" " II. . .		30,038.33		6,575.48		36,613.81
" " III. . .		30,873.03		7,009.88		37,882.91
" " IV. . .		21,395.05		4,552.08		25,947.13
TOTAL OF MASONRY .		103,245.13		22,718.49		125,963.62
GRAND TOTAL OF SUBSTRUCTURE . . .		$185,233.41		$35,094.90		$220,328.31

In this table the freight charges have been stated separately, so as to make a basis for comparison with other works, the cost without freight charges practically representing what the cost of the work would have been at Chicago prices.

The shore ends of the approach spans were originally carried on Cushing cylinders filled with concrete resting on piles. These Cushing piers are shown on Plate 3. The Cushing pier at the west end settled badly during the grading of the approach; the weight of the approach span was therefore transferred to a crib resting on the embankment, this crib being built up as the settlement continued. In June, 1885, a block of concrete 12′ by 24′ by 6′ was built on the embankment 66 feet back of the Cushing pier, and this block of concrete now supports the west end of the approach span which has replaced the shorter span originally built, while the portion of the Cushing pier above ground has been entirely removed. The east Cushing pier remains in its original position, having been pressed forward only a few inches by the building of the embankment.

The number of cubic yards of masonry and concrete in the entire work is as follows: —

	Masonry.	Concrete.	Total.
East Cushing Pier	1.7	67.2	68.9
Pier I.	1081.7	1198.7	2280.4
Pier II.	1562.4	589.4	2151.8
Pier III.	1578.9	592.3	2171.2
Pier IV.	1108.4	1205.6	2314.0
West Cushing Pier (abandoned)	1.7	48.4	50.1
Concrete Block	2.4	66.7	69.1
TOTAL	5337.2	3768.3	9105.5

V.

SUPERSTRUCTURE.

The superstructure consists of three through spans and two short deck spans in the approaches. The through spans are 330 feet long between centers of end pins, and the deck spans were 110 feet long, but the west approach span was subsequently replaced by a 176 feet span. The entire superstructure was manufactured by the pound from designs prepared by the engineer of the bridge, complete shop drawings being furnished to the contractor.

On November 6th, 1882, a circular was addressed to prominent bridge manufacturers inviting them to make proposals for the construction of the superstructure. In response to this invitation, five proposals were received. These proposals were opened in New York on the 2d day of December, 1882, and the work was awarded to the Keystone Bridge Company, which was the lowest bidder.

The trusses of the 330 feet through spans are divided into fifteen panels of 22 feet each; they are of the double system Whipple type, with inclined end posts, are 44 feet deep, and spaced 20 feet between centers. The top chords, end posts, bolsters, rollers, bearing plates, pins, and the eye-bars in the nine central panels of the bottom chords are of steel; all other parts are of wrought iron excepting the heavy wall plates resting on the masonry, the washers, and the ornamental work, which are of cast iron. The details of these spans are given on Plates 12–16. The deck spans are shown on Plates 17, 18.

The trusses were not proportioned to carry any particular class of locomotives or cars now in use, but for general conditions which are believed to include the heaviest class of rolling-stock which is ever likely to be used, and to make a provision for the increased effect of a moving load on the central members of the web. The dead load in the long spans was taken at 30,000 pounds per panel. The actual weight of each span, including 450 pounds per foot of timber floor, and rails, was 929,035 pounds, equivalent to 30,968 pounds per panel if averaged over the whole bridge. Inasmuch as a portion of this weight is carried directly by the masonry, and as the reduction in weight from the use of steel occurs principally in the central panels, the assumed weight per panel is more nearly correct than the average weight. The moving load provided for in the trusses was 3,000 pounds to the foot, except that, in proportioning the web, the excess of maximum strain in any member over and above the strain in that member under a uniform load of equal intensity was taken on a basis of 5,000 pounds per foot, instead of 3,000. The floor system is proportioned for a load of 5,000 pounds per foot throughout. The top lateral system is designed to resist a wind strain of 300 pounds per lineal foot and the bottom lateral system 500 pounds per lineal foot, the whole being taken as a moving load. The strain sheets are given on Plate 19.

The weights of iron and steel in the 330 feet spans are as follows: —

	Three Spans.		Average per Span.
	Pounds.	Pounds.	Pounds.
Steel	. . . .	884,548	294,849
Wrought Iron in Trusses	1,012,343		
" " Floor	434,805		
Total Wrought Iron		1,447,148	482,383
Cast Iron	. . . .	57,322	19,107
Total	. . . .	2,389,018	796,339

The weights of iron and steel in the deck spans are as follows: —

	110′ Span.	176′ Span.
	Pounds.	Pounds.
Steel	4,979	6,753
Wrought Iron	110,503	238,550
Cast Iron	8,955	4,325
Total	124,437	249,628

The specifications under which the superstructure was manufactured are given in Appendix G.

The steel blooms were manufactured by the Cambria Iron Company, at Pittsburg, Penn., and the steel was rolled by Carnegie Brothers and Company, Limited, at the Union Iron Mills in Pittsburg. A full record of the tests of sample bars was kept, and fourteen full-sized bars were broken at Watertown. The behavior of these full-sized bars was excellent, the only bars which failed to meet the requirements of the specifications being bars which would have been condemned without the test. The only point in which the specifications were changed was, that the required reduction in the samples of tension steel was changed from 45 per cent. to 42 per cent. A summary of the records of tests of full-sized bars with the analyses is given in Appendix H.

The superstructure was erected on staging, consisting of bents reaching to the level of the lower chord, with a large traveler and without the use of upper false work. The false work under the easterly long span rested on the ground, that under the other two long spans on piles. The west approach deck span was raised in June, 1883. The erection of the false work for the easterly through span was begun August 5th, the raising of iron began August 16th, the trusses were connected through by August 22d, and the floor was all put in by the 24th. Pile-driving for the false work for the central span was begun on August 13th, the raising of iron was begun September 5th, and the trusses were coupled up on September 9th. The false work for the westerly through span was begun September 17th, the erection of iron began on October 16th, and the trusses were coupled up on the 19th, the floor being put in by the 22d. The raising of the last span was delayed about a week by the accidental destruction of the traveler. The east approach span was raised in September. The entire erection was handled by Mr. William Baird, for the Keystone Bridge Company.

The floor system is shown on Plate 11. It consists of 9 by 9 oak ties, generally 12 feet long, spaced about 15 inches between centers. These ties rest on iron stringers 9 feet between centers. The track is laid with a 60-pound steel rail. Inside the rails are placed two lines of 5 by 4 by ½-inch angle irons, bolted to every tie with 1-inch bolts; these angle irons acting as guard rails in case of derailment, and also holding the ties together. A timber ribbon 10 by 10 inches, faced 12 feet over all, is bolted to every fourth tie, and a narrow footway and wire rope hand-rail complete the floor.

The bridge was formally tested in the presence of a committee of engineers, and opened for traffic October 27th, 1883. The official report of the engineers who observed this test is given in Appendix I. A new west approach span was erected in August, 1885, and the old span was taken down and used at the crossing of White River.

VI.

APPROACHES.

The east approach is 10,175 feet long from the connection with the main track of the Sioux City and Pacific Railroad to the east end of the iron-work. The west approach is 6,208 feet long from the western end of the iron-work to its connection with the Sioux City and Pacific Railroad. The total length of main line belonging to the Missouri Valley and Blair Railway and Bridge Company, including the bridge itself, is 17,717 feet. The alignment and grades are shown on Plate 3.

The 3,000 feet of the eastern approach adjoining the bridge were built in the form of a timber trestle; this trestle was divided into three sections of 1,000 feet each, called respectively Trestles I., II., and III. All the trestles were built in 16 feet spans. Trestle No. I. was built of pine timber, resting on oak piles, with a floor of 12 feet oak ties. Trestle No. II. was built of pine timber on pine piles with 8 feet ties; its construction being generally somewhat cheaper than that of Trestle No. I. Trestle No. III. was built of cottonwood timber on cottonwood piles, but with pine stringers and ties. The trestles were built by Mr. N. Desparois, of Sioux City, the company furnishing the timber. The part of the approach east of Trestle No. III. is an earth embankment, the material for which was borrowed from the sides, the higher portion adjoining Trestle No. III., however, being left below grade till after the opening of the bridge, the track being carried in part on a temporary blocking. After the opening of the bridge, the embankment was filled out with earth hauled by trains from the west side. In the fall of 1883, the lower part of Trestle No. III. was filled by scraping in sand from the sides. During the winter of 1883–4 the steam-shovel was kept at work in the big cut east of Blair, and the filling of the trestle was begun. The portion of Trestles II. and III. which is across the slough channel (shown on Plate 3) was filled to an elevation of about 1040 during this winter. The breaking up of the ice in March, 1884, carried away the whole of Trestle No. I. and 600 feet of Trestle No. II., being all of the trestle-work which had not then been rendered secure by filling. The filling, however, of the slough channel had the effect of permanently closing that channel, and when the flood receded, the sand-bar was left in good condition for work. The 1,600 feet of trestle which had been destroyed were replaced at once with a trestle similar to Trestle No. II., except that it was built in 20 feet spans. During 1884, the whole of Trestle No. III. and all that was left standing of Trestle No. II. were filled to grade by trains; the base of the new trestle was filled to elevation 1021 by scraping material from the sides, and to elevation 1030 by trains. The whole timber trestle was filled to grade in 1885, though some widening remains to complete the bank.

The west approach consists of a graded railroad in cut and fill from a connection with the Sioux City and Pacific track eastward to Fish Creek; then of a trestle 1,184 feet long, with a short span of Howe truss at the east end, from the west side of Fish Creek to the east side of the old Sioux City and Pacific track; and of a solid embankment from this trestle to the western end of the iron-work. The approach west of Fish Creek was graded by contract in the fall of 1882. The trestle was built by Mr. N. Desparois, on the same terms as the trestles on the east side. The embankment between the trestle and the bridge was built of earth excavated by the steam-shovel and unloaded from a light cottonwood trestle built for the purpose. On July 19th, 1883, this embankment had been carried about to grade to a point as far as Station 4. During that night a sudden settlement of 6 feet took place, the ground at the sides being forced up about 6 feet. An examination by borings revealed the fact that a layer of soft mud existed below the surface, which evidently marked the course of an old river channel; the filling was continued, and the embankment finally brought to grade, though not until the ground at each side had risen about 14 feet and the settlement so far as it could be ascertained was over 40 feet. The old channel crossed the line of the approach diagonally, and entered the river about 300 feet above the bridge line. If the original location selected for the bridge had been adhered to, this trouble would have been much less serious. The eastern end of the approach was leveled off to the full width of the final embankment at an elevation of 1039, and on this a temporary timber trestle 220 feet long was erected, so as to complete the approach in season for the opening of the bridge. During the interruption of 1884 this embankment was raised to the level of 1054, and in November of the same year it was brought up to grade. Only a slight settlement occurred until after the embankment was brought to grade, when a most rapid settlement, which amounted to nearly 10 feet, took place at the end of the iron-work, the cylinders which carried the approach span being carried down with the bank, but it caused no interruption of train service. A slight movement in the top of Pier IV., though not more than could be explained by a very moderate compression in the timber and crib-work of the foundations, showed that the bank was exerting a pressure against this pier. As the short approach span could be used elsewhere, it was thought best to replace this by a longer span, and slope off the end of the embankment, which was accordingly done in the summer of 1885.

VII.

COST.

THE cost of the bridge, approaches, and rectification works is shown in the following table. It will be observed that the cost of the rectification work formed an unusually large amount of the whole expenditure. The item of freight includes generally the freight from Chicago to the bridge site, and from the quarries to the bridge site. In comparing the cost of this bridge with that of other structures, the cost without freight forms the most correct basis for comparison.

	Cost exclusive of Freight Charges.		Freight Charges.		Cost including Freight Charges.	
Protection East Shore . . .	$39,033.08		$27,566.67		$66,599.75	
Protection West Shore .	108,394.58		103,710.06		212,104.64	
Dike	66,811.07		56,185.35		122,996.42	
Protection Works, Total		$214,238.73		$187,462.08		$401,700.81
East Trestle	28,104.37		5,374.41		33,478.78	
East Embankment . .	77,012.32		1,495.78		78,508.10	
West Trestle	14,545.41		1,922.62		16,468.03	
West Embankment	61,993.87		251.54		62,245.41	
Approaches, Total .		181,655.97		9,044.35		190,700.32
Foundation, Pier I. .	22,355.26		4,020.53		26,375.79	
" Pier II.	17,383.97		2,199.38		19,583.35	
" Pier III. . .	19,845.50		2,398.80		22,244.30	
" Pier IV. . .	22,403.55		3,757.70		26,161.25	
Foundations, Total .		81,988.28		12,376.41		94,364.69
		$477,882.98		$208,882.84		$686,765.82

	Cost exclusive of Freight Charges.		Freight Charges.		Cost including Freight Charges.	
Brought forward . . .		$477,882.98		$208,882.84		$686,765.82
Approach Piers . . .		5,149.98		1,345.90		6,495.88
Masonry, Pier I . . .	$20,938.72		$4,581.05		$25,519.77	
" Pier II.	30,038.33		6,575.48		36,613.81	
" Pier III. .	30,873.03		7,009.88		37,882.91	
" Pier IV. .	21,395.05		4,552.08		25,947.13	
Masonry, Total .		103,245.13		22,718.49		125,963.62
Main Spans . . .	171,676.38		4,082.14		175,758.52	
Approach Spans . .	19,229.29		393.28		19,622.57	
Floor . . .	6,801.32		1,670.30		8,471.62	
Painting	2,629.69		43.08		2,672.77	
Superstructure, Total .		200,336.68		6,188.80		206,525.48
Main Tracks .	22,919.11		1,009.03		23,928.14	
Service Tracks . .	22,996.45		64.96		23,061.41	
Tracks, Total		45,915.56		1,073.99		46,989.55
Engineering, Salaries .	24,010.41				24,010.41	
Engineer's Office, Expenses .	3,041.13				3,041.13	
Engineering, Total .		27,051.54				27,051.54
Tools and Machinery .		12,074.51		295.37		12,369.88
Buildings . . .		5,472.50		343.81		5,816.31
Land Damages . .		9,112.76				9,112.76
TOTAL . . .		$886,241.64		$240,849.20		$1,127,090.84

	Cost exclusive of Freight Charges.	Freight Charges.	Cost including Freight Charges.
Brought forward	$886,241.64	$240,849.20	$1,127,090.84
Cost of Washout Repairs, Spring of 1884	23,199.18	3,619.46	26,818.64
Cost of Steam-Shovel, Freight Cars, Ballast Unloaders, etc. .	18,984.53	221.97	19,206.50
Undistributed Material . . .	1,190.71	392.90	1,583.61
GRAND TOTAL	$929,616.06	$245,083.53	$1,174,699.59

This table may be condensed into the following: —

	Cost exclusive of Freight Charges.	Freight Charges	Cost including Freight Charges
Substructure	$190,383.39	$36,440.80	$226,824.19
Superstructure	200,336.68	6,188.80	206,525.48
Total, Bridge Proper . . .	390,720.07	42,629.60	433,349.67
Approaches	181,655.97	9,044.35	190,700.32
Protection Works	214,238.73	187,462.08	401,700.81
Tracks	45,915.56	1,073.99	46,989.55
Buildings and Tools	17,547.01	639.18	18,186.19
Real Estate	9,112.76		9,112.76
Engineering	27,051.54		27,051.54
TOTAL	$886,241.64	$240,849.20	$1,127,090.84

APPENDIX A.

LIST OF ENGINEERS, EMPLOYEES, AND CONTRACTORS.

ENGINEERS AND COMPANY'S EMPLOYEES.

NAME AND OCCUPATION	TIME OF SERVICE.
Geo S. Morison, Chief Engineer.	
H. W. Parkhurst, First Assistant Engineer	June 14, 1882, to Nov. 10, 1883.
Emil Gerber, Assistant Engineer	Aug. 1, 1882, " Nov. 1, 1883.
" " Resident Engineer	Nov. 1, 1883, " date.
S. W. Y. Schimonsky, Draughtsman	April 18, 1883, " July 15, 1883.
G. W. Lilly, Assistant Engineer	Sept. 6, 1882, " Mar. 30, 1883.
W. S. Macdonald, Office Assistant	Dec. 8, 1882, " Nov. 8, 1883.
A. C. Shelley, Inspector of Transportation	Nov. 2, 1882, " Jan. 15, 1883.
C. C. Schneider, Assistant Engineer of Superstructure.	
W. F. Zimmermann, Inspector of Superstructure.	
G. C. Henning, Inspector of Superstructure.	
Robert Ross, Inspector of Masonry	Dec. 23, 1882, to May 15, 1883.
P. Aylward, Foreman of Pressure Work	Oct. 10, 1882, " April 30, 1883.
Dennis Brophy, Steam Engineer and Machinist	Sept. 15, 1882, " May 17, 1883.
James Saguin. Foreman of Carpenters, Caisson Building	Sept. 20, 1882, " June 15, 1883.
J. A. McKeen Foreman of Laborers	Dec. 10, 1881, " date.
N. Oman, Foreman of Carpenters, Bridge Floor, etc.	June 1, 1883, " Nov. 17, 1883.

CONTRACTORS.

NAME.	NATURE OF WORK.
Lyman Brothers	Earth work of Approaches.
N. Desparois	Trestle-work of Approaches.
T. Saulpaugh & Co.	Masonry.
P. Durack, Foreman of Masons.	
O. Davis, Foreman of Stone Cutters.	
Keystone Bridge Co.	Superstructure.
Baird Brothers, Erection of Superstructure.	
W. H. B. Stout	Riprap.
Le Grand Quarry Co.	Riprap.
Jasper Stone Co.	Riprap.
A. G. Seney	Riprap.

APPENDIX B.

SPECIFICATIONS FOR MASONRY.

THE masonry will be first-class rock-face work, laid in regular courses, to be built of limestone from the quarries near Mankato, Minnesota, except the up-stream starlings of Piers II. and III., which, for a height of 30 feet, beginning about 8 feet below low water, will be of granite.

The piers shall conform in all respects to the plans furnished by the engineer.

No course shall be less than 16 inches thick, and no course shall be thicker than the course below it.

The upper and the lower bed of every stone shall be at least one quarter greater in both directions than the thickness of the course, and no face stone shall measure less than 30 inches in either horizontal direction.

In general, every third stone of each course shall be a header, and there shall be at least two headers on each side of each course between the shoulders. No stone will be considered a header that measures less than 5 feet back from the face. The headers shall be so arranged as to form a bond entirely through the pier, either by bonding against a face stone in the opposite side of the course, or by bonding with a piece of backing not less than 3 feet square, which shall bond with a face stone on the opposite side. In all cases the interior bonding shall be further secured by placing in the course above a stone at least 3 feet square over the interior joints. Special care shall be taken with the bonding of the ice-breaker cut-water, the stones of which shall be so arranged that the face stones are supported from behind by large pieces of backing.

All joints shall be pitched to a true line, and dressed to $\frac{1}{4}$ inch for at least 12 inches from the face. Beds, both upper and lower, shall be pitched to a true line, and dressed to $\frac{1}{2}$ inch. Joints shall be broken at least 15 inches on the face. The bottom bed shall always be the full size of the stone

The granite starlings of Piers II. and III. shall have a smooth bush-hammered face. There shall be a draft line 3 inches wide around the lower edge of the belting course below the coping, and on the edge of the pointed starlings. The coping over the whole pier, and the small copings over the pointed starlings, shall have a smooth bush-hammered surface and face. All other parts of the work shall have a rough quarry face, with no projections exceeding 3 inches from the pitch lines of the joints.

The stones in the coping under the bearings of the trusses shall be at least 3 feet wide, and shall reach entirely across the pier. They shall have good beds for their entire size, and shall have a full bearing on large stones with dressed beds in the belting course below the coping.

The stones of the backing shall be of the same thickness as the face stones, and shall have dressed beds.

All stones shall be sound, free from seams or other defects, and shall be laid on their natural beds.

All stones shall be laid in full mortar beds. They shall be lowered on the bed of mortar, and brought to a bearing with a maul. No spalls will be allowed except in small vertical openings in the backing. Thin mortar joints will not be insisted on, but the joints shall be properly cleaned on the face and pointed in mild weather, the pointing to be driven in with a calking-iron.

The face stones of each course in Piers II. and III. for a height of 26 feet, beginning about 3 feet below low water, shall be doweled into those of the course below with round dowels of $1\frac{1}{8}$-inch iron, extending 6 inches into each course; the dowels shall be from 8 to 12 inches back from the face, and 6 inches on each side of every joint; the stones of the upper course shall be drilled through before setting, after which the drill hole shall be extended 6 inches into the lower course; a small quantity of mortar shall then be put into the hole, the dowel dropped in and driven home, and the hole filled with mortar and rammed. The two courses below the copings shall have the joints bound with cramps of $\frac{7}{8}$-inch round iron, 20 inches long between shoulders, the ends sunk 3 inches into each stone.

The mortar will be composed of cement and clean coarse sand, satisfactory to the engineer, in proportions varying from one to three parts of sand to one of cement, as may be directed by the engineer for different parts of the work. When stone is laid in freezing weather, the contractor shall take such precautions to prevent the mortar's freezing as shall be satisfactory to the engineer. The stone shall be cut at the quarries.

No material shall be measured, or included in the estimate, which does not form a part of the permanent structure.

Any stone transported from the quarries and left over from the work will be the property of the bridge company.

APPENDIX C.

LIST OF BORINGS.

NOTE. — In locating borings the Bridge Line is understood as follows: Station 0, center of Pier IV.; line runs east. The West Approach is understood as follows: Station 0, center of Pier IV.; line runs west.

Boring No. 1, 775 feet north of Station 17, Bridge Line.

Fine bar sand	45.0	feet.
Coarse sand and blue clay	7.0	"

Rock at elevation 959.8.
(Drilled 1.5 feet into rock.)

Boring No. 2, 850 feet north of Station 12, Bridge Line.

Fine bar sand	39.0	feet.
Coarse sand and pebbles	12.5	"
Quicksand	0.33	"
Blue clay	0.33	"

Gray rock at elevation 958.5.
(Drilled 1.08 feet into rock.)

Boring No. 3, 650 feet north of Station 12, Bridge Line.

Fine bar sand	49.4	feet.
Blue clay	0.5	"

Rock at elevation 958.9.
(Drilled 3.25 feet into rock.)

Boring No. 4, 1,000 feet north of Station 2 + 40, Bridge Line.

Dark soil	3.0	feet
Mixed material	22.0	"
Fine sand	21.0	"
Blue clay	1.0	"
Coarse sand and pebbles	11.25	"
Shell rock (at elevation 955.8)	0.70	"
Fine black sand	0.37	"

Solid rock at elevation 954.7.
(Drilled 2.5 feet into rock.)

Boring No. 5, 1,050 feet north of Station 2 + 60, West Approach.

Gumbo	46.0	feet.
Black sand	6.0	"
Blue clay	0.3	"
Gravel and sand	16.7	"
Shell and clayey rock at elevation 953.3	2.2	"

(Drilled into this 1.5 feet.)

Boring No. 6, 500 feet south of Station 10, Bridge Line.

Fine bar sand	48.0	feet.
Coarse sand and pebbles	12.0	"

Rock at elevation 954.0
(Drilled 0.92 feet into rock, taking 32 hours' drilling.)

Boring No. 7, 700 feet south of Station 10, Bridge Line.

Fine bar sand and pebbles	45.0	feet.
Gravel	17.0	"
Shell rock	0.16	"
Clean coarse sand	1.08	"

Solid rock at elevation 950.6.
(Drilled 0.92 feet into rock.)

Boring No. 8, 200 feet south of Station 10, Bridge Line.

Fine bar sand	40.0	feet.
Coarse sand and pebbles	16.4	"

Solid rock at elevation 955.9.
(Drilled 0.83 feet into rock.)

Boring No. 9, Station 10, Bridge Line.

Fine bar sand, with a few pebbles and some clay	55.67	feet.
Shell rock	0.12	"
Fine sand and rotten rock	0.70	"

Solid rock at elevation 956.7.
(Drilled 2.25 feet into rock.)

Boring No. 10, Station 0, Bridge Line.

Black soil	2.0	feet
Gumbo	23.0	"
Dark sand	13.0	"
Coarse sand	2.0	"
Sand, pebbles, and clay	2.0	"
Black sand	10.0	"
Coarse sand	8.0	"
Fine sand, pebbles, and some clay	3.0	"
Fine black sand	6.5	"

Elevation of rock 954.8.
(Drilled 3.33 feet into rock.)

Boring No. 11, Station 9, Bridge Line

Fine sand	21.0	feet
Mud	2.0	"
Fine sand	13.0	"
Coarse sand	19.33	"

Rock at elevation 956.01.

Boring No. 12, Station 5 + 32, Bridge Line.
Surface of water, elevation 1007.9.

Fine sand	28.0	feet.
Mud	4.0	"
Fine sand	17.0	"
Coarse sand	4.75	"

Rock at elevation 954.15.

Boring No. 13, Station 4 + 32, Bridge Line.
Surface of water, elevation 1007.3.

Water	8.0	feet.
Fine sand	19.0	"
Mud	3.0	"
Fine sand	12.0	"
Coarse sand	11.67	"

Rock at elevation 953.63.

Boring No. 14, Station 2 + 32, Bridge Line.
Elevation of water 1008.5.

Water	22.0	feet.
Fine sand	17.0	"
Coarse sand	3.0	"
Gumbo	6.0	"
Coarse sand	6.83	"

Rock at elevation 953.7.

Boring No. 15, Station 1 + 32, Bridge Line.
Elevation of water 1008.7.

Water	24.0	feet.
Fine sand	23.0	"
Gumbo	4.0	"
Sand and some gumbo	4.17	"

Rock at elevation 953.53.

Boring No. 16, 30 feet south of Station 10 + 15, Bridge Line.

Fine sand	29.0	feet
Coarse sand	3.0	"
Blue clay	0.6	"
Fine sand mixed with some clay	17.0	"
Coarse sand	5.0	"

Rock at elevation 957.0.
(Drilled 4.25 feet into rock.)

APPENDIX C. — CONTINUED.

Boring No. 17, 30 feet south of Station 9 + 85, Bridge Line.

Fine sand	35.0 feet.
Snag	0.6 "
Fine sand	8.0 "
Coarse sand	5.4 "
Blue clay	4.0 "
Coarse sand	2.9 "

Rock at elevation 956.77.

Boring No. 18, 30 feet north of Station 10 + 15, Bridge Line.

Fine sand	32.5 feet.
Coarse sand	13.5 "
Fine sand	2.0 "
Coarse sand, and some clay	7.17 "

Rock at elevation 957.69.

Boring No. 19, 30 feet north of Station 9 + 85, Bridge Line.

Fine sand	40.0 feet.
Coarse sand, with some clay	11.0 "
Coal (lignite)	0.5 "
Coarse sand	3.83 "

Rock at elevation 957.64.

Boring No. 20, 30 feet north of Station 6 + 50, Bridge Line.

Fine sand	40.0 feet.
Coarse sand	14.7 "

Rock at elevation 954.44.
(Drilled 3.67 feet into rock.)

Boring No. 21, 30 feet south of Station 6 + 80, Bridge Line.

Fine sand	31.7 feet.
Mud	3.0 "
Fine sand	1.3 "
Coarse sand	16.5 "
Fine sand	2.5 "

Rock at elevation 954.34.

Boring No. 22, 30 feet south of Station 6 + 50, Bridge Line.

Quicksand	33.0 feet.
Gumbo and sand	4.5 "
Blue clay	0.9 "
Fine sand	14.5 feet.
Coarse sand	1.0 "
Sandstone (?) (probably limestone).	0.7 "

Rock at elevation 954.0.

Boring No. 23, 30 feet north of Station 6 + 80, Bridge Line.

Fine sand	42.8 feet.
Blue clay and sand	2.2 "
Coarse sand	11.17 "

Rock at elevation 955.02.

Boring No. 24, 30 feet north of Station 3 + 45, Bridge Line.
Water surface at elevation 1005.4.

Water	16.0 feet.
Fine sand	20.0 "
Coarse sand and some gumbo	7.0 "
Gumbo	3.0 "
Coarse sand	2.0 "
Blue clay	1.0 "
Gravel	1.9 "

Rock at elevation 954.5.

Boring No. 25, 30 feet south of Station 3 + 15, Bridge Line.
Water elevation 1005.4.

Water	16.0 feet.
Fine sand	20.0 "
Coarse sand	5.0 "
Gumbo	6.0 "
Coarse sand	2.0 "
Blue clay	1.5 "
Gravel	1.0 "

Rock at elevation 953.9.
(Drilled 1.33 feet into rock.)

Boring No. 26, 30 feet north of Station 3 + 15, Bridge Line.
Water elevation 1007.3.

Water	16.0 feet.
Fine sand	21.0 "
Coarse sand and gumbo	3.0 "
Gumbo	7.0 "
Sand with a little clay	5.8 "
Slate-stone (limestone)	0.6 "

Rock at elevation 953.9.
(Drilled 4.25 feet into rock.)

Boring No. 27, 30 feet south of Station 3 + 45, Bridge Line.
Surface of water, elevation 1007.3.

Water	12.0 feet.
Fine sand	18.0 "
Coarse sand	21.0 "
Blue clay	1.0 "
Gravel	1.0 "

Rock at elevation 954.3.

Boring No. 28, 30 feet south of Station 0 + 15, Bridge Line.

Sand and clay	25.0 feet.
Coarse sand	11.0 "
Lignite	2.0 "
Coarse sand	15.0 "
Gumbo	3.92 "
Rock	1.96 "
Clay	0.21 "

Rock at elevation 952.14.

Boring No. 29, 30 feet north of Station 0 + 15, Bridge Line.

Gumbo	8.6 feet.
Sand and clay	19.4 "
Blue clay	5.0 "
Fine sand	19.0 "
Coarse sand	4.5 "
Gravel	3.0 "
Fine sand	10.0 "

Rock at elevation 955.47.
(Drilled 0.6 feet into rock.)

Boring No. 30, 30 feet north of Station 0 + 15, West Approach.

Gumbo	9.0 feet.
Sand and clay	17.5 "
Blue clay	13.5 "
Fine sand	15.0 "
Coarse sand	4.0 "
Fine sand	8.5 "
Sand and clay	2.83 "

Rock at elevation 954.37.

NOTE. — Borings Nos. 28, 29, and 30 were made in the pit excavated for Caisson IV., which excavation was about 13.0 feet deep, mostly through a gumbo soil with a little sand in the lower part of the pit, as indicated by the notes of the borings which refer to the original surface of the ground in Nos. 29 and 30.

APPENDIX D.

ACCOUNT OF CEMENT USED.

PORTLAND CEMENT.

MANUFACTURED BY ALSEN & SONS, ITZEHOE.

Masonry.

Pedestal Castings	5 bbls.	
Pier I.	255 "	
Pier II.	294 "	
Pier III.	521 "	
Pier IV.	217 "	
Total in masonry		1,292 bbls.

Concrete.

Pier I.	2,288 bbls.		
Pier II.	1,193 "		
Pier III.	1,170 "		
Pier IV.	1,881 "		
Approach Piers	83 "		
Total in concrete		6,615 bbls.	
Balance left over or sold		111 "	
Total Portland Cement			8,018 bbls.

MILWAUKEE CEMENT.

Pier I.	266 bbls	
Pier II.	366 "	
Pier III.	117 "	
Pier IV.	360 "	
Approach Piers	279 "	
Miscellaneous and left over	102 "	
Total Milwaukee Cement		1,490 bbls.

Total Portland Cement	8,018 bbls.
Total Milwaukee Cement	1,490 "
Total Cement purchased	9,508 bbls.

APPENDIX E.

RECORD OF SINKING CAISSONS.

PIER I.

NOTE.—Readings taken at 8 A.M.

Date	Gauge Readings N.E.	N.W.	S.W.	S.E.	Average	Datum	Average Elevation of Cutting Edge	Sinking in 24 Hours	Elevations of Sand N.E.	N.W.	S.W.	S.E.	Average	Average Penetration in Sand
1882 Dec.														
[illegible]	4.55	4.40	4.61	4.49	4.51	1017.60	1013.09	—	1012.77	1012.[illegible]	1012.55	1012.50	1012.64	—
23	—	—	—	—	4.51	1017.60	1013.09			—			[illegible]	
26	—	—	—	—	4.51	1017.60	1013.09	-	-	—	-	—	[illegible]	
27	5.58	5.52	6.10	5.98	5.79	1017.57	1011.[illegible]	1.31	—	—	—	—	1001.00	—
28	8.47	8.57	9.00	8.88	8.73	1017.14	1008.41	3.37		—		-	1010.40	2.01
29	11.[illegible]	11.38	11.49	11.50	11.40	1017.61	1006.21	2.20	1009.08	1009.74	1009.46	1008.95	1009.18	2.97
30	12.86	11.86	13.00	13.04	12.44	1017.71	1005.27	.94	1010.[illegible]	1010.08	1011.53	1010.67	1010.86	5.59
31	18.70	19.06	18.96	18.48	18.8[illegible]	1020.14	1001.32	3.95	1010.30	1013.70	1013.75	1011.80	1012.44	[illegible]
1883. Jan.														
1	20.80	21.15	20.70	20.22	20.72	1019.[illegible]	998.47	2.85	1009.39	1013.77	1013.11	1012.09	1012.34	13.77
2	23.30	23.14	23.21	22.84	23.20	1019.30	996.[illegible]	2.3	1010.70	1013.65	1013.18	1011.34	1012.[illegible]	16.[illegible]
3	25.32	25.37	25.33	25.34	25.34	1010.33	993.98	[illegible]	1010.37	1010.90	1011.30	1010.74	1010.83	16.85
4	28.[illegible]	28.00	28.08	28.09	27.54	1019.34	991.80	2.18	1009.41	1009.54	1007.24	1008.84	1008.70	16.06
5	29.30	29.[illegible]	30.08	30.23	29.70	1017.73	988.03	3.77	1008.06	1007.98	1008.2[illegible]	1008.13	1008.11	20.08
6	33.55	33.14	33.17	33.38	33.36	1018.51	985.15	2.88	1007.57	1007.01	1007.88	1007.01	1007.37	22.[illegible]
Feb.														
15	33.55	33.14	33.[illegible]	33.58	33.36	1018.51	985.15			—	—	—		
16	33.99	33.54	33.66	34.08	33.82	1018.69	985.07	.08	1009.[illegible]	1009.68	1011.69	1010.04	1010.30	25.23
17	[illegible]	34.50	34.79	35.1[illegible]	34.85	1019.04	984.1	.88	1012.94	1009.14	1013.64	1007.04	1010.69	26.50
18	37.88	37.57	37.94	38.25	37.91	1018.33	986.47	3.77	1004.73	1007.63	1017.63	1006.93	1007.98	27.56
19	39.75	39.43	40.10	40.44	39.93	1018.31	[illegible]76.38	2.04	1004.81	1004.91	1011.41	1000.01	1006.[illegible]8	28.40
20	[illegible]3.07	43.04	43.10	43.28	43.12	1018.85	[illegible]	2.65	1004.[illegible]	1004.0	1010.[illegible]	1005.8	1006.48	30.[illegible]5
21	46.88	46.05	46.[illegible]5	46.78	46.7	1020.35	973.[illegible]8	2.15	1004.37	1005.70	1008.[illegible]0	1005.37	1005.76	3[illegible].18
22	49.00	[illegible]	49.31	49.42	49.42	1021.07	971.[illegible]	1.93	1005.2	1005.0	1005.[illegible]	1004.[illegible]	1005.82	34.17
23	47.00	46.71	46.72	46.83	46.82	1018.4	971.65	.00	1006.[illegible]	1006.1	1008.7	1007.[illegible]	1006.97	3[illegible]
24	50.[illegible]	50.36	50.06	50.1[illegible]	50.31	1019.25	968.94	2.71	1006.3	1006.3	1007.8	1007.0	1006.65	37.91
25	[illegible]9.47	49.21	[illegible]9.07	49.04	49.17	1018.00	968.02	.02	1006.[illegible]	1005.0	[illegible]	1005.8	1006.30	37.38
26	[illegible]	[illegible]	51.[illegible]	51.[illegible]	51.54	1018.11	966.57	[illegible]35	1006.8	1005.1	1005.0	1006.9	1006.70	40.13
27	55.05	54.7[illegible]	54.66	54.64	54.[illegible]8	1019.03	964.75	[illegible]32	1004.6	1004.7	1005.[illegible]	1005.3	1005.12	40.57
28	60.46	60.36	60.15	60.24	60.35	1022.02	961.74	2.51	1003.9	1003.7	1005.0	1005.[illegible]	1004.45	42.[illegible]
Mar.														
1	60.88	60.67	60.5[illegible]	60.6[illegible]	60.67	1023.39	961.72	.02	1004.9	1004.5	1005.5	1004.7	1004.90	43.68
2	62.43	62.20	62.04	62.15	62.20	1021.[illegible]	959.24	2.18	1004.[illegible]	1005.0	1004.8	1004.2	1004.72	45.18
3	63.27	63.05	63.05	63.[illegible]7	63.[illegible]6	1020.77	[illegible]5.61	1.63	1005.1	1004.9	1005.3	1003.4	1004.65	47.07
4	63.16	62.84	62.85	63.05	62.99	1020.47	95[illegible].48	.13	1004.6	1005.2	1005.9	1004.9	1005.15	47.[illegible]
5	61.65	61.35	61.37	61.57	61.48	1018.95	957.47	0.[illegible]			—	—		—

Date	Water Gauge	Depth Immersed	Weights: Caisson	Crib	Masonry	Sand	Total	Air Pressure: Indicated	Calculated	Resistance due to Air Pressure	Net weight	Surface in contact	Average Weight per sq. ft. of Surface exposed	Remarks
			Tons	Tons	Tons	Tons	Tons	lbs.	lbs.	Tons	Tons		lbs.	
1882 Dec.														
[illegible]	—		137		—		137	-	-	-	137		—	Caisson on jacks. Began excavating under it ... A.M.; excavated about 2 ft.
23	—		137		—	.	137	—	-	—	137	—	.	Caisson undisturbed. Began placing jacks under it.
26			137	—	—	—	137	—	—	—	13[illegible]	—	.	No work done ... Sunday and Christmas. Began lowering on jacks.
27	1007.6	—	137	—		—	13[illegible]	-	—		137		—	Jacks removed ... afternoon.
28	1008.[illegible]		137		—		137	—		—	137	314	874	
29	1008.55	2.34	141	-	—	—	141	—	—	—	141	463	609	Air pressure put on at 8 A.M. Cameron pumps started at 10 A.M.; concreting at 10.30 A.M.
30	1011.30	6.03	242	—		—	242	3.50	2.845	266	[illegible]	87[illegible]	[illegible]55	
31	1011.1[illegible]	10.10	382			—	382	5.00	4.335	405	[illegible]3	1735	[illegible]	
1883. Jan.														
1	1008.90	10.43	541			—	541	6.50	4.476	4.8	133	2148	114	Began putting on crib in A.M. Caisson filled at 6 P.M.
2	1008.80	12.70	683	12	—	-	695	7.00	5.151	508	187	2993	144	Began filling crib at 7 A.M.
3	1008.70	11.[illegible]	683	158			841	7.30	6.318	590	251	[illegible]	[illegible]	
4	1008.80	16.80	683	290		—	973	8.25	[illegible]10	673	300	[illegible]	[illegible]27	
5	1009.03	21.00	683	442	-	30	1155	10.50	9.0[illegible]3	841	314	3132	[illegible]00	Air pressure blown off at 6.15 P.M. Work begun on caisson for Pier III.
6	1008.45	23.30	683	573	—	52	1308	—	—	—	—	—	—	From Jan. 6th to Feb. 15th crib finished and four courses of masonry put on.
Feb.														
15	—	—			—		—	—		—		—	-	Air pressure put on at 5 A.M. Cameron pumps started at 4 P.M.
16	1012.46	27.39	683	1201	399	83	2366	11.75	11.755	1097	1269	3930	645	
17	1012.[illegible]	27.93	683	1201	399	96	2379	13.25	11.987	1119	1260	4134	610	
18	1011.63	32.20	683	1201	399	106	2389	14.00	13.520	1210	1099	4299	511	
19	1008.87	30.19	683	1201	399	115	2398	14.50	13.086	[illegible]	1177	4430	531	
20	1008.85	33.12	683	1201	399	139	2[illegible]22	16.00	14.[illegible]15	1326	1096	4[illegible]97	457	
21	1008.58	35.00	683	1201	408	53	2445	16.50	15.0[illegible]1	1402	1043	5070	415	
22	1009.17	37.57	683	1201	406	174	25[illegible]4	17.75	16.103	1503	1021	5330	383	
23	1001.[illegible]	3[illegible].96	683	1201	508	185	2537	18.00	16.29[illegible]	1570	11[illegible]7	55[illegible]0	405	
24	1009.23	40.20	683	1201	664	270	2768	20.00	17.[illegible]92	1614	1154	5914	390	
25	1008.78	39.[illegible]	683	1201	[illegible]05	200	2795	19.75	17.107	1596	1199	5[illegible]31	4[illegible]1	
26	1009.43	4[illegible].50	683	1201	[illegible]05	280	2869	21.00	18.266	1[illegible]04	1165	6260	37[illegible]	
27	1008.[illegible]0	44.45	683	1201	793	300	2977	21.00	19.0[illegible]7	1780	1197	6376	375	
28	[illegible]	4[illegible].[illegible]0	683	1201	8[illegible]0	339	3093	21.00	20.129	1878	1215	6663	3[illegible]5	
Mar.														
1	1009.43	47.71	683	1201	850	3[illegible]	3109	21.50	20.476	1911	1198	6[illegible]36	356	
2	1000.0[illegible]	49.81	683	1201	850	471	3205	22.50	21.378	1995	1210	7095	341	
3	100[illegible].[illegible]7	51.16	683	1201	850	537	3271	23.00	21.957	2040	1222	[illegible]343	333	Cameron pumps stopped at 8 A.M. Began filling working chamber at 11 A.M.
4	1001.[illegible]	51.88	683	1201	850	562	3296	24.00	22.266	2075	1218	7[illegible]3	328	
5					—	—					—		—	Air pressure taken off at 10 A.M.

APPENDIX E. — Continued.

RECORD OF SINKING CAISSON FOR PIER II.

Note. — Readings taken at 8 A. M.

Date.	Gauge Readings N.E.	N.W.	S.W.	S.E.	Average.	Datum	Average Elevation of Cutting Edge	Sinking 24 Hours	Elevations of Sand N.E.	N.W.	S.W.	S.E.	Average	Average Penetration of Caisson	Water Gauge	Depth Immersed	Weights Caisson	Masonry	Sand	Total	Air Pressure Indicated	Calculated	Reaction due to Air Pressure	Net Weight	Surface in Contact	Average Weight per Square Foot of Surface exposed to Friction	Remarks
1882 Nov.																	Tons.	Tons.	Tons.	Tons.	Lbs.	Lbs.	Tons	Tons		Lbs.	
16	—	—	—	—	—	—	1007.30	—	1008.15	1008.10	1007.86	1007.94	1008.01	0.71	1007.4	0.1	146	—		146	—		—	146	111	2636	Before filling caisson with concrete
20		—					1006.47		1008.15	1008.10	1007.86	1007.94	1008.01	1.54	1007.30	0.83	708			708	—	—	—	708	240	5000	After filling caisson with concrete. Commenced sinking at 7 A.M., Nov. 22d.
23	5.30	5.40	5.50	5.40	5.40	1011.34	1005.94	0.53	1008.68	1009.09	1008.32	1007.98	1008.52	3.58	1008.40	2.46	712	1		713		1.056	99	614	407	3055	
24	4.77	4.75	5.48	5.45	5.11	1008.94	1003.83	2.11	1009.17	1009.5	1008.96	1007.27	1008.75	4.92	1008.04	5.11	712	57		769		2.194	205	564	768	1469	
25	6.35	6.00	6.55	6.45	6.34	1008.50	1002.16	1.67	1009.27	1009.76	1009.11	1007.62	1008.94	6.78	1008.50	6.34	712	208	—	920	—	[illegible]	254	666	1058	1259	
26	10.85	10.78	10.50	10.60	10.68	1008.80	998.12	4.04	1009.55	1010.02	1009.50	1007.95	1009.25	11.13	1008.80	10.68	712	284	—	996	—	4.584	428	568	1736	654	
27	16.15	16.11	17.17	17.27	16.68	1008.90	992.22	5.90	1009.45	1009.82	1009.57	1008.30	1009.29	17.07	1008.90	16.68	712	415		1127	—	7.159	668	459	2663	345	
28	28.73	28.57	28.32	28.58	28.55	1017.59	989.04	3.18	1008.20	1009.52	1010.27	1008.86	1009.23	20.19	1008.86	19.82	712	566	57	1335		8.506	794	541	3150	344	
29	32.80	32.70	32.50	32.80	32.70	1016.76	984.06	4.98	1007.11	1007.59	1010.08	1007.55	1008.08	24.02	1009.59	25.53	712	680	168	1560		10.957	1022	538	3747	[illegible]	
30	37.03	36.88	36.93	37.13	36.99	1016.68	979.69	4.37	1006.98	1005.48	1005.98	1006.56	1006.25	26.56	1008.15	28.46	712	850	262	1828	—	12.215	1140	684	4143	330	From 985 to 978, sand mixed with balls of clay.
Dec.																											
1	34.10	34.05	34.40	34.35	34.23	1013.65	979.42	0.27	1007.70	1007.45	1007.65	1007.65	1007.61	28.19	1007.85	28.43	712	983	322	2017		13.203	1135	878	4398	399	
2	35.98	35.93	36.48	36.63	36.26	1014.63	978.37	1.05	1006.75	1006.75	1006.55	1006.45	1006.63	28.26	1007.15	28.78	712	1110	325	2147	—	12.352	1153	994	4409	451	Settled gradually of its own weight. 978 to 974, silt.
3	36.00	37.80	37.70	38.00	37.88	1014.85	976.97	1.40	1005.75	1005.35	1005.85	1005.95	1005.60	28.63	1006.85	29.88	712	1241	339	2292	—	12.824	1197	1095	4466	490	
4	39.84	39.74	40.14	40.34	40.02	1014.78	974.76	[illegible]	1006.24	1005.17	1006.44	1005.64	1005.87	31.11	1007.44	32.68	712	1241	433	2390	—	14.026	1309	1081	4853	445	Caisson commenced sinking instantly when pressure was reduced
5	42.30	42.25	42.45	42.82	42.45	1015.04	972.59	2.17	1007.24	1004.19	1006.97	1007.72	1006.34	33.75	1007.09	34.50	712	1358	533	2603	17.25	14.807	1382	1221	5265	464	
6	44.70	44.47	44.57	44.72	44.62	1015.24	970.62	1.97	1006.94	1004.27	1006.87	1007.32	1006.35	35.73	1006.87	36.25	712	1471	611	2794	16.00	15.558	1456	1338	5574	480	
7	44.45	44.50	44.62	44.80	44.59	1015.01	970.42	0.20	1006.86	1003.71	1007.41	1007.61	1006.42	36.00	1007.76	37.34	712	1482	621	2815	20.00	16.026	1495	1320	5646	470	974 to 968, sand, gravel, clay, &c.
8	45.93	45.80	45.78	46.01	45.88	1014.45	968.57	1.85	1006.55	1003.35	1006.90	1005.55	1005.61	37.04	1008.55	39.98	712	1483	662	2857	20.00	17.116	1597	1260	5778	430	
9	51.73	51.74	51.45	51.70	51.63	1019.76	968.13	0.14	1007.76	1007.36	1004.51	1007.91	1006.90	38.77	1007.46	39.33	712	1483	731	2928	19.00	16.881	1575	1351	6048	447	
10	52.67	52.62	52.53	52.80	52.65	1018.42	965.77	2.36	1007.95	1008.57	1008.56	1008.75	1008.46	42.69	1008.00	42.23	712	1595	850	3196	20.00	18.124	1691	1505	6660	452	
11	54.85	54.72	54.60	54.96	54.78	1018.16	963.38	2.39	1007.05	1008.56	1009.00	1008.48	1008.29	44.91	1008.46	45.08	712	1595	980	3287	20.75	19.348	1805	1482	7006	423	
12	56.39	56.35	56.12	56.33	56.30	1017.30	961.00	2.38	1006.17	1008.73	1009.37	1007.86	1008.02	47.02	1008.32	47.32	712	1707	1008	3487	21.50	20.309	1895	1592	7335	434	
13	58.62	58.51	58.30	58.62	58.51	1017.34	958.83	2.17	1006.94	1006.28	1008.79	1008.65	1007.66	48.83	1008.23	49.40	712	1768	1144	3624	23.25	21.202	1978	1646	7617	432	
14	59.77	59.66	59.34	59.69	59.62	1016.69	957.07	1.76	1004.99	1006.60	1008.75	1007.79	1007.03	49.96	1007.79	50.72	712	1768	1191	3671	24.00	21.768	2031	1640	7794	421	
15	60.56	60.44	60.10	60.48	60.40	1016.71	955.81	1.26	1005.35	1004.84	1007.99	1006.20	1006.07	50.26	1008.36	52.55	712	1768	1204	3684	25.00	22.554	2105	1579	7841	403	Weight and friction evenly balanced.
16	60.14	60.17	60.09	60.40	60.28	1015.59	955.31	0.50	1007.70	1006.09	1007.64	1006.84	1006.94	51.63	1007.76	52.47	712	1768	1202	3742	24.00	22.519	2101	1641	8054	40[illegible]	Caisson settled by equalizing through air-lock.
17	57.[illegible]	57.[illegible]	57.04	57.92	57.81	1015.12	955.31	0.00	1005.89	1005.76	1007.66	1006.10	1006.23	50.92	1007.1[illegible]	51.88	712	1768	1232	3712	23.50	22.166	2078	1634	7944	411	
18	60.59	60.4[illegible]	60.[illegible]	60.53	60.44	1015.43	954.99	0.32	1005.53	1005.31	1007.45	1005.75	1006.01	51.02	1007.33	52.34	712	1768	1236	3716	24.00	22.164	2096	1670	7959	407	Commenced filling caisson. Pressure taken off Dec. 20th.

APPENDIX E. — Continued.

RECORD OF SINKING CAISSON FOR PIER III.

Note. — Readings taken at 8 A. M.

Date	Gauge Readings. N. E.	N. W.	S. W.	S. E.	Average.	Datum.	Average Elevation of Cutting Edge.	Sunk in 24 Hours.	Elevations of Sand. N. E.	N. W.	S. W.	S. E.	Average of Twelve Soundings.	Average Penetration of Caisson.	Water Gauge.	Depth Immersed.	Weights. Caisson.	Masonry.	Sand.	Total.	Air Pressure. Indicated.	Calculated.	Reaction due to Air Pressure.	Net Weight.	Surface in Contact.	Average Weight per Square Foot of Surface exposed to Friction.	Remarks.
1883 Jan.																	Tons.	Tons.	Tons.	Tons.	Lbs.	Lbs.	Tons.	Tons.		Lbs.	
6	3.09	3.05	3.05	2.97	3.05	1013.35	1010.30	—	—	—		—	—	—	1008.20	-	147	—	—	147	—	—	—	147	—	—	Caisson suspended on screws. Commenced lowering Jan. 5th, 10 A. M.
9	11.29	11.2[illegible]	11.2[illegible]	11.20	11.24	1013.15	1001.91	8.39	-			—	—		1007.75	5.84	147	—	—	147	—	—		147			Commenced filling with concrete at 7 A. M.
10	13.28	13.28	[illegible]	12.68	13.08	1013.0	999.93	1.98	994.06	994.13	99[illegible].00	1000.68	996.95		1007.70	7.77	250	—	—	250				250	—	—	Caisson on sand at S. E. corner. Air pressure put on at 5.30 P. M.
11	13.05	12.98	[illegible]	[illegible]	13.02	[illegible]	999.86	.07	[illegible]	[illegible]	991.00	1000.60	996.80	—	1007.68	7.80	368			368	5.50	3.377	315	53	—	—	Cameron pumps started at 2.30 P. M.
12	14.3[illegible]	[illegible]	14.27	13.97	14.21	1012.83	998.62	1.24	994.10	994.50	997.30	1000.20	997.33	—	1007.59	8.47	521	—	—	521	7.00	3.883	[illegible]	[illegible]	—	—	Screws removed at 11.30 A. M.
13	18.50	17.40	[illegible]	18.49	18.16	1013.51	995.41	3.21	[illegible]	994.10	[illegible]	999.3	996.30	3.49	1007.59	[illegible]	691	—	—	691	7.00	[illegible]	492	199	554	718	
14	20.99	20.50	21.60	[illegible]	21.30	1012.63	991.43	3.98	992.8	993.2	[illegible]	[illegible]	997.51	6.08	1007.57	16.14	691	114		805	9.00	6.087	652	153	948	323	
15	24.17	23.94	24.86	24.94	[illegible]	1013.19	988.71	2.72	993.4	[illegible]	1003.1	999.3	998.15	9.44	1007.6[illegible]	18.63	691	237		928	9.00	[illegible]	765	163	[illegible]	[illegible]	
16	26.15	26.01	[illegible]	26.36	[illegible]	[illegible]	987.68	1.03	993.1	992.8	1004.2	1000.8	[illegible]	11.03	1007.65	19.97	691	424	—	1115	9.00	8.645	807	308	1730	358	
17	[illegible]	31.05	30.84	30.83	30.97	1013.85	982.88	4.80	[illegible]	[illegible]	1005.7	[illegible]	[illegible]	17.34	1007.67	24.79	691	585	[illegible]	1278	11.50	[illegible]	[illegible]	[illegible]	[illegible]	205	
18	[illegible]	34.33	34.8	34.81	[illegible]	1013.15	[illegible]	4.43	995.3	996.5	1003.4	1002.6	1000.37	[illegible]	1007.70	29.25	691	734	91	1516	13.50	12.662	[illegible]	334	3304	196	
19	37.02	[illegible]	[illegible]	[illegible]	[illegible]	1012.80	975.93	[illegible]	[illegible]	[illegible]	1002.9	1001.3	999.99	24.06	1007.75	[illegible]	691	838	161	1690	14.50	13.715	1285	405	[illegible]	[illegible]	
20	[illegible]	36.80	36.82	36.93	36.89	1012.80	975.91	.02	[illegible]	993.8	[illegible]	1001.5	1000.03	24.12	1007.76	31.85	691	839	163	1693	15.00	13.788	1287	[illegible]	[illegible]	210	
21	[illegible]	[illegible]	37.08	[illegible]	[illegible]	1013.09	[illegible]	.00	995.9	993.9	1003.0	1001.6	1000.07	[illegible]	1007.90	[illegible]	691	839	165	1695	[illegible]	[illegible]	[illegible]	403	[illegible]	[illegible]	
22	37.00	36.84	36.85	[illegible]	36.93	[illegible]	[illegible]	.01	[illegible]	[illegible]	1003.0	1001.1	999.87	23.97	1007.95	[illegible]	691	830	158	[illegible]	15.00	[illegible]	1295	393	[illegible]	213	21°
23	[illegible]	37.17	37.23	37.32	[illegible]	[illegible]	975.90	.00	990.0	[illegible]	[illegible]	1001.7	[illegible]	24.01	1008.01	32.11	691	933	159	1783	15.00	13.900	[illegible]	[illegible]	[illegible]	200	
24	[illegible]	40.40	40.48	[illegible]	40.51	[illegible]	973.21	2.69	[illegible]	993.8	1003.0	1001.3	1000.15	26.04	1008.00	34.79	691	1093	[illegible]	[illegible]	17.50	15.001	1405	646	4203	307	
25	44.38	[illegible]	44.30	44.41	44.33	1017.53	[illegible]	.01	[illegible]	992.1	1003.9	[illegible]	1000.78	[illegible]	1008.08	[illegible]	691	[illegible]	291	[illegible]	[illegible]	15.100	1409	807	[illegible]	375	
26	[illegible]	[illegible]	42.42	42.27	[illegible]	1012.80	970.54	2.66	998.9	991.7	[illegible]	1001.3	1000.40	29.80	1008.03	37.51	691	1313	[illegible]	[illegible]	19.75	16.238	1515	895	[illegible]	384	
27	[illegible]	42.15	[illegible]	[illegible]	[illegible]	[illegible]	970.52	.02	999.3	[illegible]	1004.0	1001.1	1000.96	30.44	1007.89	37.47	691	[illegible]	398	[illegible]	20.50	[illegible]	1514	1051	[illegible]	[illegible]	
28	[illegible]	45.55	[illegible]	45.08	45.66	1013.53	968.1	[illegible]	998.9	993.5	1004.5	1000.9	1000.76	[illegible]	1007.81	39.69	691	1557	480	2728	22.00	17.183	1603	[illegible]	5084	443	
29	[illegible]	45.44	45.72	[illegible]	[illegible]	1013.72	968.17	.00	998.9	994.5	1005.3	1000.7	1001.36	33.9	1007.79	[illegible]	691	1557	503	[illegible]	22.00	17.152	1600	1151	5178	444	
30	48.02	[illegible]	[illegible]	[illegible]	48.04	[illegible]	[illegible]	[illegible]	997.5	994.4	1004.7	1000.5	1000.94	35.3	[illegible]	42.07	691	1557	586	2834	[illegible]	[illegible]	1699	1135	5508	412	
31	48.00	[illegible]	48.39	[illegible]	48.08	[illegible]	965.03	.00	998.6	994.7	1005.1	1000.6	1001.43	35.86	[illegible]	[illegible]	691	1557	605	2853	19.75	18.173	1696	[illegible]	[illegible]	414	
Feb.																											
1	49.70	[illegible]	49.55	49.33	49.33	1013.47	[illegible]	[illegible]	997.0	995.1	1004.8	1000.5	1000.95	[illegible]	1007.57	44.43	691	1635	684	3010	[illegible]	[illegible]	[illegible]	[illegible]	5808	[illegible]	
2	49.85	[illegible]	[illegible]	49.95	[illegible]	1013.04	[illegible]	.02	[illegible]	[illegible]	1001.5	1000.2	1001.36	[illegible]	[illegible]	[illegible]	691	1717	[illegible]	[illegible]	21.50	19.208	[illegible]	131	[illegible]	442	
3	[illegible]	52.31	52.18	51.93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1003.4	1000.1	[illegible]	40.45	[illegible]	[illegible]	691	1717	[illegible]	[illegible]	23.25	[illegible]	1885	[illegible]	6310	401	
4	52.38	52.37	52.19	52.01	52.20	1012.83	[illegible]	.04	[illegible]	999.8	1003.4	[illegible]	[illegible]	[illegible]	1007.32	[illegible]	691	1717	818	[illegible]	24.00	[illegible]	1886	1340	[illegible]	418	
5	[illegible]	[illegible]	[illegible]	58.30	[illegible]	[illegible]	[illegible]	2.95	[illegible]	998.8	[illegible]	1000.0	1001.18	43.70	[illegible]	[illegible]	691	[illegible]	[illegible]	[illegible]	24.50	21.459	[illegible]	[illegible]	[illegible]	390	
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00	[illegible]	999.9	[illegible]	1000.4	[illegible]	44.59	1007.16	49.48	691	[illegible]	[illegible]	[illegible]	23.75	[illegible]	1909	1431	[illegible]	412	
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1003.9	1000.4	[illegible]	[illegible]	1007.22	[illegible]	691	1781	1010	[illegible]	24.00	[illegible]	2091	1421	[illegible]	391	
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1001.2	[illegible]	47.45	[illegible]	[illegible]	691	1781	1076	3548	24.50	[illegible]	2108	1440	7407	391	
9	59.46	59.31	59.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	997.5	1000.1	[illegible]	1001.1	[illegible]	[illegible]	[illegible]	[illegible]	691	1781	[illegible]	[illegible]	21.00	[illegible]	2136	1446	[illegible]	386	Cameron pumps stopped at 5 A. M.
10	[illegible]	59.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.01	[illegible]	1000.1	[illegible]	[illegible]	[illegible]	[illegible]	1007.28	52.64	691	1781	[illegible]	[illegible]	[illegible]	[illegible]	2126	[illegible]	[illegible]	[illegible]	
11	59.54	[illegible]	[illegible]	[illegible]	59.40	1013.03	[illegible]	.10	[illegible]	[illegible]	[illegible]	1001.3	1003.11	48.00	[illegible]	[illegible]	691	1781	1137	3009	[illegible]	[illegible]	2135	[illegible]	7628	386	
12	[illegible]	[illegible]	59.64	[illegible]	59.71	[illegible]	[illegible]	.11	[illegible]	1000.5	[illegible]	1001.1	1003.53	49.10	[illegible]	53.05	691	1781	[illegible]	[illegible]	24.00	22.005	2143	1470	7060	385	Commenced filling working chamber at 3.10 P. M.
13	[illegible]	60.10	[illegible]	60.02	60.08	1014.23	[illegible]	.28					—	—	1007.54	53.39	691	1781									
14	[illegible]	60.04	59.94	59.97	60.07	[illegible]	[illegible]	.00																			
15	[illegible]	60.05	[illegible]	59.98	60.03	[illegible]	[illegible]	.01		—	—					—	—	—			—		—	—	—	—	Air pressure taken off at 3.40 A. M.

APPENDIX E. — CONTINUED.

RECORD OF SINKING CAISSON FOR PIER IV.

NOTE. — Readings taken at 8 A. M.

Date	Gauge Readings N. E.	Gauge Readings N. W.	Gauge Readings S. W.	Gauge Readings S. E.	Gauge Readings Average	Datum	Average Elevation of Cutting Edge	Sunk in 24 Hours	Elevations of Sand N. E.	Elevations of Sand N. W.	Elevations of Sand S. W.	Elevations of Sand S. E.	Elevations of Sand Average	Average Penetration of Caisson	Water Gauge	Depth Immersed	Weights Caisson	Weights Crib	Weights Masonry	Weights Sand	Weights Total	Air Pressure Indicated	Air Pressure Calculated	Reaction due to Air Pressure	Net Weight	Surface in Contact	Average Weight per Square Foot of Surface exposed to Friction	Remarks
1883 Mar.																	Tons.	Tons.	Tons.	Tons.	Tons.	Lbs.	Lbs.	Tons.	Tons.		Lbs.	
7	20.86	21.37	21.15	21.17	21.14	1029.34	1008.20		1007.5	1010.4	1009.2	1010.1	1009.80	1.60	—	—	138	—		—	138	—	—		138	750	1 04	Empty caisson resting on mud
8	[illegible]	21.92	21.50	21.32	21.55	[illegible]	1007.91		1010.1	1010.8	[illegible]	1010.4	1010.38	2.47	1012.40	4.49	138	—		—	138	—	—	—	138	365	717	
9	[illegible]	21.61	21.75	21.01	21.27	1029.18	1007.91		1010.5	1011.6	1010.5	1010.3	1010.73	[illegible]	1013.44	5.53	138		—	—	138		—		138	440	627	Commenced filling with concrete at 11 A. M.
10	21.28	21.61	21.35	21.06	21.31	1029.16	1007.85	.06	1010.4	1011.5	1010.7	1010.4	1010.75	[illegible]	[illegible]	4.98	188		—		188				188	452	832	
11	[illegible]	21.69	21.78	[illegible]	21.74	[illegible]	1007.46	.39	1010.4	[illegible]	1010.4	1010.4	1010.60	3.14	1009.90	[illegible]	289			—	289	—	—		289	490	1179	
12	[illegible]	21.64	21.76	21.81	21.71	[illegible]	1007.43	.03	1010.4	1011.2	1010.8	1010.4	1010.70	3.27	1009.58	[illegible]	289	—	—	—	289	—	—	—	289	510	1133	
13	21.91	[illegible]	[illegible]	[illegible]	22.18	1029.21	1007.03	.40	1010.4	1011.2	1010.8	1010.4	1010.70	3.67	1009.25	[illegible]	436	—	—	—	436	—	—		436	[illegible]	1524	
14	[illegible]	23.05	[illegible]	22.75	[illegible]	1029.10	[illegible]	.82	1010.1	1011.0	1011.6	1009.1	[illegible]	4.24	1011.16	4.75	608	—	—		608				608	661	1840	
15	22.10	[illegible]	22.85	22.41	[illegible]	1028.71	1006.19	.07	1010.1	1011.0	1010.4	1010.3	[illegible]	4.51	1009.55	3.36	697	—	—	—	697			—	697	704	1980	
16	[illegible]	[illegible]	23.07	[illegible]	[illegible]	[illegible]	1006.16	.03	1010.4	1011.0	1011.3	1009.5	1010.65	4.49	1007.95	3.79	697	4		—	701	—	—	—	701	700	2003	Commenced building crib.
17	[illegible]	[illegible]	23.30	[illegible]	22.96	[illegible]	1006.16	.00	1010.2	1011.5	1011.8	[illegible]	1010.85	4.69	1010.59	4.43	697	21	—	—	718	—	—		718	732	1962	Air pressure put on at 5 P. M. Cameron pumps started at 9 P. M.
18	[illegible]	[illegible]	23.13	[illegible]	[illegible]	1028.94	1006.16	.00	1010.8	1011.4	1011.3	1010.0	1010.88	[illegible]	[illegible]	4.49	697	30	—		727	3.00	1 944	181	546	736	1484	
19	25.28	[illegible]	23.17	[illegible]	[illegible]	1029.14	1004.88	.28	1010.9	1011.4	1011.6	1011.2	1011.28	6.40	[illegible]	6.56	697	36	—		733	3.00	2 840	265	468	998	938	Commenced filling crib
20	[illegible]	26.80	23.65	23.52	[illegible]	1029.75	1004.64	.24	[illegible]	[illegible]	[illegible]	1009.5	1011.55	6.9	1009.97	5.33	697	111	—	—	808	4.00	[illegible]	215	593	1078	1100	
21	25.96	26.63	[illegible]	25.83	26.26	1029.05	[illegible]	1.85	[illegible]	[illegible]	[illegible]	1009.7	1011.38	8.59	1009.50	6.71	697	256		—	953	5.00	[illegible]	271	682	1340	1015	
22	28.07	29.43	28.05	27.48	[illegible]	[illegible]	1001.01	[illegible]	[illegible]	1011.6	1010.8	1012.9	1011.75	[illegible]	1009.12	8.11	697	[illegible]	—		1109	4.75	[illegible]	328	781	1675	933	
23	[illegible]	[illegible]	[illegible]	30.69	30.64	[illegible]	998.77	[illegible]	[illegible]	1010.9	1011.5	1011.4	1011.62	12.85	1008.90	[illegible]	697	583	—		1280	6.75	4 385	409	871	2005	869	
24	31.54	[illegible]	30.83	[illegible]	31.21	1028.90	997.69	1.08	[illegible]	[illegible]	1011.3	1012.5	1011.90	14.71	1011.10	13.41	697	622	—		1319	8.25	5 805	[illegible]	777	[illegible]	701	
25	[illegible]	[illegible]	[illegible]	[illegible]	33.22	1028.90	[illegible]	1.92	[illegible]	1012.3	[illegible]	1011.5	1011.95	16.18	[illegible]	18.33	697	625		—	[illegible]	[illegible]	7 935	740	582	[illegible]	401	
26	[illegible]	[illegible]	33.53	33.35	33.86	[illegible]	[illegible]	[illegible]	1012.4	1012.5	1011.5	1011.1	1011.88	16.48	[illegible]	18.03	697	628		—	[illegible]	[illegible]	7 805	[illegible]	597	[illegible]	464	
27	37.01	[illegible]	[illegible]	35.61	36.39	[illegible]	[illegible]	2.32	[illegible]	[illegible]	[illegible]	[illegible]	1011.58	18.50	[illegible]	19.81	697	644	—	14	1355	9.50	8 576	800	555	2886	385	
28	37.50	[illegible]	[illegible]	36.05	36.57	[illegible]	[illegible]	.00	1011.6	[illegible]	1011.4	[illegible]	1011.55	[illegible]	1012.50	[illegible]	697	659	—	13	1369	10.25	[illegible]	784	585	288	406	
29	36.92	[illegible]	[illegible]	35.07	36.39	[illegible]	[illegible]	.06	1011.3	1010.8	1011.0	1012.4	1011.38	18.30	1011.84	[illegible]	697	659	—	12	1368	[illegible]	8 147	760	608	[illegible]	[illegible]	
30	[illegible]	[illegible]	[illegible]	38.80	38.69	1029.65	991.35	1.07	1011.0	1010.8	1010.7	1010.9	1011.10	[illegible]	1011.92	[illegible]	697	[illegible]		[illegible]	1445	11.00	8 905	831	614	3051	399	
31	[illegible]	40.43	[illegible]	[illegible]	40.90	1029.06	988.70	2.59	1010.0	1009.5	1010.5	1011.1	1010.28	[illegible]	1011.88	23.12	697	860	—	44	1601	11.75	10.009	934	667	3357	397	
Apr.																												
1	44.19	44.19	44.56	44.71	44.41	1029.66	985.25	3.51	1010.0	1010.3	1010.1	1009.1	1010.03	[illegible]	1011.75	26.50	697	1048	–	78	1823	13.00	11 473	1070	753	3866	390	Caisson settled of its own accord in P. M. of March 31st. Crib with 13′ 9″ of full
2	46.44	46.68	[illegible]	[illegible]	46.58	1029.27	[illegible]	[illegible]	1009.0	1009.9	1010.5	1009.0	1009.60	[illegible]	[illegible]	[illegible]	697	1202	—	99	1998	15.00	12 506	1167	831	4198	396	
3	48.18	[illegible]	48.44	[illegible]	48.34	1028.70	[illegible]	[illegible]	1009.7	1010	1009.7	1008	1009.53	29.17	1011.64	[illegible]	697	1253	—	122	2072	15.75	13 541	1263	809	4551	356	
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.44	1009.6	1010.3	1010.6	[illegible]	1009.80	31.88	[illegible]	33.70	697	1253	170	150	[illegible]	[illegible]	[illegible]	1303	857	4073	345	
5	[illegible]	[illegible]	45.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1010.8	1010.6	1008.4	1009.60	34.31	[illegible]	[illegible]	697	1253	197	175	[illegible]	17.75	15 810	[illegible]	[illegible]	5352	316	
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1009.6	1010.0	[illegible]	1007.9	1009.48	[illegible]	1011.03	39.02	697	1253	[illegible]	201	[illegible]	[illegible]	16.593	1576	991	[illegible]	[illegible]	
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1008.0	1009.0	1009.5	1007.4	[illegible]	[illegible]	[illegible]	[illegible]	697	1253	488	237	[illegible]	[illegible]	17.887	1669	1006	6008	335	
8	61.53	[illegible]	61.40	[illegible]	[illegible]	1029.37	[illegible]	2.04	1008.5	[illegible]	[illegible]	1010.3	1009.40	41.47	[illegible]	[illegible]	697	1253	615	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1151	6469	[illegible]	
9	63.41	63.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.20	[illegible]	[illegible]	1008.8	[illegible]	[illegible]	42.87	[illegible]	[illegible]	697	1253	[illegible]	351	[illegible]	22.00	19.570	[illegible]	1119	6688	335	
10	[illegible]	[illegible]	58.53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1008.2	[illegible]	[illegible]	[illegible]	[illegible]	45.30	[illegible]	[illegible]	697	1253	725	[illegible]	[illegible]	23.50	20.571	1970	[illegible]	[illegible]	340	
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	960.28	2.87	1007.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	697	1253	774	610	3334	25.00	21.835	2037	1297	[illegible]	344	
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.33	[illegible]	1009.9	[illegible]	[illegible]	[illegible]	51.33	1011.41	53.46	697	1253	867	[illegible]	[illegible]	[illegible]	[illegible]	2160	[illegible]	[illegible]	[illegible]	
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1009.00	[illegible]	[illegible]	56.09	697	1253	975	831	3756	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.08	1007.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	697	[illegible]	[illegible]	819	[illegible]	28.50	[illegible]	[illegible]	1578	[illegible]	350	
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	57.00	697	1253	[illegible]	[illegible]	[illegible]	25.00	[illegible]	2303	1771	8528	404	Caisson settled on rock at 8.30 A. M., April 14th
[illegible]	74.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00																				

APPENDIX F.

DETAILED STATEMENT OF TIME, COST, AND ALSO MATERIALS USED IN FOUNDATIONS.

PIER I.

Date 1882	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub Foremen Days	Sub Foremen Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Days	Pressure Men Amount	Coffee House Men Days	Coffee House Men Amount
Dec.												
22	1	$6.00	–		2	$6.00	3	$4.50	18½	$41.62	1	$1.50
23	1	6.00	1	$3.33	3	9.00	2	4.50	19	42.75	1	1.50
24	1	6.00	1	3.33			[illegible]	4.50			–	
25	1	6.00	1	3.33	–		1	2.25	—	—	1	1.50
26	1	6.00	1	3.33	2	6.00	2	4.50	15.6	35.10	1	1.50
27	1	6.00	1	3.33	2	6.00	2	4.50	24	54.00	1	1.50
28	1	6.00	1	3.33	3½	10.50		–	30.4	68.40	1	1.50
29	1	6.00	1	3.33	2	6.00	2	4.50	16	36.00	2	3.00
30	1	6.00	1	3.33	2	6.00	2	4.50	23	51.75	2	3.00
31	1	6.00	1	3.33	3	9.00	2	4.50	23	51.75	2	3.00
1883 Jan.												
1	1	6.00	1	3.33	3	9.00	2	4.50	23	51.75	2	3.00
2	1	6.00	1	3.33	3	9.00	2	4.50	21	47.25	2	3.00
3	1	6.00	1	3.33	3	9.00	2	4.50	23	51.75	2	3.00
4	1	6.00	1	3.33	3	9.00	2	4.50	24	54.00	2	3.00
5	1	6.00	1	3.33	2	6.00	2	4.50	24	54.00	2	3.00
6		—		—	1	3.00	–	—	8	18.00		
Feb.												
15	¾	4.50	½	1.78	3	9.00	1½	3.50	21	47.25	1½	2.25
16	1	6.00	1	3.57	4	12.00	2	4.50	27	60.75	2	3.00
17	1	6.00	1	3.57	4	12.00	2	4.50	25	56.25	2	3.00
18	1	6.00	1	3.57	4	12.00	2	4.50	29	65.25	2	3.00
19	1	6.00	1	3.57	4	12.00	2	4.50	36	[illegible]	2	3.00
20	1	6.00	1	3.57	4	12.00	2	4.50	30.8	[illegible]	2	3.00
21	1	6.00	1	3.57	4	12.75	2	5.00	29.1	65.50	2	3.00
22	1	6.00	1	3.57	4	[illegible]	2	5.00	29	[illegible]	2	3.00
23	1	6.00	1	3.57	4	12.75	2	5.00	29	[illegible]	2	3.00
24	1	6.00	1	3.57	4	[illegible]	2	5.00	[illegible]	71.00	2	3.00
25	1	6.00	1	[illegible]	4	12.75	2	5.00	31	[illegible]	2	3.00
26	1	6.00	1	3.57	3½	[illegible]	2	5.00	30	75.00	2	3.00
27	1	6.00	1	3.57	4	[illegible]	2	5.00	30	75.00	2	3.00
28	1	6.00	1	3.57	4	13.00	2	5.00	33	82.50	2	3.00
Mar.												
1	1	6.00	1	[illegible]	3	9.75	2	5.00	32	80.00	2	3.00
2	1	6.00	1	3.22	4	13.00	2	5.00	28.5	71.25	2	3.00
3	1	6.00	1	3.22	4	13.00	2	5.00	31	[illegible]	2	3.00
4	1	6.00	1	[illegible]	4	13.00	2	5.00	[illegible]	[illegible]	2	3.00
5	1	6.00	1	3.22	4	13.00	2	5.00	29	72.50	2	3.00
6	½	3.00	½	1.61	2	6.00	½	1.13	6.2	[illegible]	½	75
Total		205.50		112.54		[illegible]		152.88		[illegible]		90.00

Date 1882	Coffee Lbs.	Coffee Amount	Sugar Lbs.	Sugar Amount	Candles No.	Candles Amount	Red Lead Lbs.	Red Lead Amount	Wick Lbs.	Wick Amount	Coal for Heating	Coal for Heating Amount	Linseed Oil Gals.	Linseed Oil Amount	Watching Boats Hrs.	Watching Boats Amount
Dec.																
22	–	—		—	—	—		—	–	—	1	$0.50		—		
23	–	—	–				–	—	–		1	50		—	—	
24		—		—				—			1	50		—		
25	–	—				—	–			—	1	50		—		
26				—	—			—			1	50		—	—	
27					6	$0.18		—	–	—	1	50		—		
28	2	$0.24	5	$0.50	22	.66	4	$0.26	¼	$0.05	1	50		$0.05	—	
29	4½	54	9	90	33	99		—			1	50		—		
30	4	.48	8	[illegible]	36	1.08				—	1	50				
31	4	[illegible]	8	[illegible]	36	1.08					1	50		—	—	
1883 Jan.																
1	5	60	8	90	15	45		—	–	—	1	50				
2	4	.48	8	96	15	45			–	—	1	50		—		
3	5½	66	6	60	18	54		—			1	50			—	
4	5	.60	9	90	24	72	–	—	–	—	1	50				
5	4½	54	7	70	23	.69		—			1	50		—		
6	1	12	2	20				—	–		1	50			—	
Feb.																
15	1	12	2	.20	18	.54		—			½	25			—	
16	4	.48	7	70	30	90	–	—	–	—	1½	75				
17	3	[illegible]	5	50	30	.90					1½	75		—		
18	4	.48	6½	65	30	.90		—			1	50			—	
19	5½	66	7½	75	30	90	–		–	—	1	50			40	$7.00
20	5	60	8	.80	36	[illegible]		—			1	50			80	11.00
21	5	60	7½	75	42	[illegible]	–	–			1	50			100	17.50
22	5	60	8	80	48	1.68			–	—	1	50		—		
23	4½	54	7	70	36	1.36		—			1	50			20	3.50
24	5	60	8	.80	42	1.47	–	—			1	50			—	
25	5	60	8	.80	36	1.30			–		1	50		—		
26	5	60	8	.80	44	1.54		—			1	50				
27	5	60	6	.60	42	1.47	–			—	1	50			–	
28	5	60	6	.60	48	1.68	–		–		1	50		—	–	
Mar.																
1	5	60	8	80	48	1.68	–			—	1	50		—		
2	4½	54	5½	55	42	1.47		—			1	50				
3	4	48	6	60	36	1.26	–			—	1	50			—	
4	5½	66	8	.80	42	1.47					1	5		—		
5	5	60	5	50	8	28		—			1	50				
6				—	—		–			—	–	—			—	
								6.00	5	1.00				70		
Total		[illegible]		20.31		30.53		[illegible]		1.05		1.75		[illegible]		32.00

Date 1882	Day Engineer Days	Day Engineer Amount	Night Engineer Days	Night Engineer Amount	Firemen Hours	Firemen Amount	Coal Passers Hours	Coal Passers Amount	Coal for Boilers Tons	Coal for Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Pints	Tallow Amount	Waste Lbs.	Waste Amount	Coal Oil Pints	Coal Oil Amount	Totals for each day	Feet sunk each day	Material	Caisson Pumps Hours run	Caisson Pumps Revolutions	Revolutions of Air Pumps	Remarks
Dec.																											
22												—				—					$60.17			—			Caisson built at [illegible] 3.09. Clearing space around caisson.
23				—	—	—	—	—	—	—	–			—			–				67.58	—					
24		—		—	—	—	—	—				—				—			–	—	14.33	—			—		
25												—	–			—				—	13.58	—		—			
26				—		—	—	—		—				—			–	—			56.93						
27		—		—	—				—			—								—	[illegible]6.01	1.3[illegible]			—		
28																					91.99	3.37					
29	1	$3.33	1	$3.00	48	$9.60	24	$4.32	16.9	[illegible]	3	$0.07	2	$0.25	4	$0.32	4	$0.40	6	$0.12	139.42	2.70		16¾	—		
30		—	1	6.00	48	9.60	24	4.32	16.5	82.50	3	07	2	25	4	32	4	40	6	12	81.18	94	Fine bar sand.	17½			
31	—	—	2	6.00	48	9.60	24	4.32	10.5	52.50	3	.07	3	37	3	24	3	30	6	12	154.12	3.95		13¾	36		
1883 Jan.																											
1			2	6.00	48	9.60	24	4.32	8.4	42.00	3	07	3	37	3	24	2	20	6	12	143.01	2.85		6¼	36		
2			2	6.00	48	9.60	24	4.32	10.5	52.50	3	07	3	37	3	24	2	30	6	12	148.89	37		9¾	36	—	
3	—	—	2	6.00	24	4.80	24	4.32	9.0	45.00	3	07	3	37	3	24	2	.20	6	12	141.00	[illegible]		7¾	36	–	
4			2	6.00	24	4.80	24	4.32	16.0	80.00	3	07	3	3	4	32	2	20	6	12	178.[illegible]	2.18		19	38		
5			2	6.00	24	4.80	24	4.32	8.0	40.00	3	07	3	37	2	16	2	30	6	12	135.30	3.77		11	46	—	
6	—	—						—		—				—			–	—			21.87	3.58			—	–	Worked [illegible] only.
Feb.																											
15	1	3.57	2	6.42	24	4.80	24	4.32	6.5	32.50	3	07	2	25	2	16	2	20	6	12	121.80	—		7	—	—	
16	1	3.57	2	6.42	24	4.80	24	4.32	8.0	40.00	3	.07	3	37	3	24	2	20	6	12	152.[illegible]	05		15	—		
17	1	3.57	2	6.42	24	4.80	24	4.32	7.5	37.50	3	07	3	37	3	24	2	20	6	12	145.50	88	Sand a little coarser,	13	36	38	
18	1	3.57	2	6.42	24	4.80	24	4.32	7.4	[illegible]	3	07	3	37	3	24	2	20	6	12	153.[illegible]	[illegible]	some trash,	21½	32	—	
19	1	3.57	2	6.42	24	4.80	24	4.32	[illegible]	37.00	3	07	3	37	3	.24	2	20	6	12	153.[illegible]	2.04	stumps, &c.	21	35	36	
20	1	3.57	2	6.42	24	4.80	24	4.32	7	38.50	3	.07	3	38	3	24	2	20	6	12	170.20	[illegible]		22¾	35	—	
21	1	3.57	2	6.42	24	4.80	24	4.32	7.8	[illegible]	3	.07	3	3	3	24	2	20	6	12	175.73	2.15	Sand in	24	34	—	
22	1	3.57	2	6.42	24	4.80	24	4.32	7.7	38.50	3	07	3	38	3	24	2	20	6	12	163.52	1.93	north end,	23	35	30	
23	1	3.57	2	6.42	24	4.80	24	4.32	7.8	39.00	3	07	3	38	3	[illegible]	2	20	6	12	16[illegible].04	0	silt and	24	36	34	
24	1	3.5[illegible]	2	6.42	24	4.80	24	4.32	7.6	38.00	3	07	3	37	3	24	2	20	6	12	172.80	2.71	clay in	22½	36	—	
25	1	3.57	2	6.42	24	4.80	24	4.32	[illegible]	38.00	3	07	3	37	3	24	2	20		12	[illegible]	02	south end	22	31		
26	1	3.57	2	6.42	24	4.80	24	4.32	7.5	37.50	3	07	3	38	3	24	2	20		12	[illegible].60	2.35	only.	23			
27	1	3.57	2	6.42	24	4.80	24	4.32	7.0	35.00	3	07	3	37	3	24	2	20	6	12	163.60	2.32		23		—	
28		3.57	2	6.42	24	4.80	24	4.32	7.5	37.50	3	07	3	38	3	24	2	20	6	12	174.07	2.51		23⅝	36	34	
Mar.																											
1	1	3.22	1	2.58	24	4.80	24	4.32	7.5	[illegible]	3	07	3	37	3	24	2	20	6	12	163.[illegible]	.02	Sand in both ends.	23	38	36	
2	1	3.22	1	2.58	24	4.80	24	4.32	7.5	37.50	3	07	3	38	3	24	2	20	6	12	157.[illegible]	[illegible]		23½	30	30	
3	1	3.22	1	2.58	24	4.80	24	4.32	5.5	27.50	3	.07	3	37	3	24	2	20	6	12	153.98	1.03		8	—		
4	1	3.23	1	2.58	24	4.80	24	4.32	[illegible]	27.50	3	.07	3	38			2	20	6	.12	[illegible].52	13		—	—	–	
5	1	3.22	1	2.58	24	4.80	24	4.32	4.5	22.50	3	07	3	37	3	24	2	20	6	12	143.07	01					
6	½	.80	½	.65	6	1.20	6	1.08	—							—		—	–		31.75				—		
																					7.70						Cutting edge at 95 4'.
Total		[illegible]		148.43		54.80		[illegible]		[illegible]		1.89		9.72		6.48		5.90		3.[illegible]4	4,6[illegible].77			344⅝			

APPENDIX F.—Continued.

TIME, COST, AND MATERIALS USED IN FOUNDATION FOR PIER II.

Date 1882	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub-Foreman Days	Sub-Foreman Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Hours	Pressure Men Amount	Coffee House Men Days	Coffee House Men Amount	Coffee Lbs	Coffee Amount	Sugar Lbs	Sugar Amount	Candles No.	Candles Amount	Red Lead Lbs	Red Lead Amount	Wick Lbs	Wick Amount	Coal for Heating Boxes	Coal for Heating Amount	Linseed Oil Gals	Linseed Oil Amount	Day Engineer Days	Day Engineer Amount	Night Engineer Days	Night Engineer Amount
Nov. 22	1	$6.00	1	$3.33	2	$6.00	2	$4.50	168	$30.37	2	$3.00					24	$0.72	—	—				$0.36	—	—	1	$3.33	4	$1.50
23	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	3½	$0.42	3	$0.30	36	1.08						30	—	—	1	3.33	1	3.00
24	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	7½	84	5½	55	36	1.08	5	$0.32	3	$0.63		30	—	—	1	3.33	1	3.00
25	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	4½	54	6½	65	24	72		—	3		10	36	—	—	1	3.33	1	3.00
26	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	4	54	6½	65	36	1.08	—	—		—		36	—		1	3.33	1	3.00
27	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	5	60	7	70	36	1.08	5	32		63		36		—	1	3.33	1	3.00
28	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	5	60	7	70	36	1.08	—	—		—		36		—	1	3.33	1	3.00
29	1	6.00	1	3.33	3	9.00	2	4.50	168	47.25	2	3.00	5	60	8	80	36	1.08	—	—		—	1	25			1	3.33	1	3.00
30	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	4½	54	8	80	36	1.08		—	—		1	25	—		1	3.33	1	3.00
Dec. 1	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	5	60	7	70	36	1.08	5	32	3	63	1	25	—		1	3.33	1	3.00
2	1	6.00	1	3.33	2	6.00	2	4.50	192	54.00	2	3.00	5	60	7	70	36	1.08	—	—	3	—	1	25		—	1	3.33	1	3.00
3	1	6.00	1	3.33	2	6.00	2	4.50	184	51.75	2	3.00	5	60	7	70	42	1.26	—	—		—	1	25		—	1	3.33	1	3.00
4	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	5	60	7	70	36	1.08	5	32	—	63	2	50			1	3.33	1	3.00
5	1	6.00	1	3.33	3	9.00	2	4.50	188	52.87	2	3.00	5	60	7	70	42	1.26			—		1	25	—		1	3.33	1	3.00
6	1	6.00	1	3.33	2	6.00	2	4.50	168	47.25	2	3.00	5	60	7	70	36	1.08	14	91	—		2	50	—		1	3.33	1	3.00
7	1	6.00	1	3.33	3	9.75	2	4.50	176	49.50	2	3.00	5	60	5	50	36	1.08	—		—		2	50		—	1	3.33	1	3.00
8	1	6.00	1	3.33	3	9.75	2	5.00	192	60.00	2	3.00	5	60	7	70	36	1.08	—	—		—	1	25		—	1	3.33	1	3.00
9	1	6.00	1	3.33	3	9.75	2	5.00	192	60.00	2	3.00	5	60	11½	1.15	36	1.08	14	91	—	—	1	25		—	1	3.33	1	3.00
10	1	6.00	1	3.33	3	9.75	2	5.00	192	60.00	2	3.00	5	60	6½	65	30	90			—	—	2	50	—		1	3.33	1	3.00
11	1	6.00	1	3.33	3	9.75	2	5.00	139	56.25	2	3.00	5	60	5	50	36	1.08			—	—	2	50	—				2	6.00
12	1	6.00	1	3.33	4	13.00	2	5.00	30	75.00	2	3.00	5	60	8	80	36	1.08	14	91	—		1	25	—				2	6.00
13	1	6.00	1	3.33	4	13.00	2	5.00	31	77.50	2	3.00	5	60	7	70	42	1.26	—	—			2	50					2	6.00
14	1	6.00	1	3.33	4	13.00	2	5.00	31	77.50	2	3.00	5	60	5	50	40	1.20	—	—			1	25					2	6.00
15	1	6.00	1	3.33	4	13.00	2	5.00	32	80.00	2	3.00	5	60	6½	65	30	90	14	91		—	2	50		—			2	6.00
16	1	6.00	1	3.33	4	13.00	2	5.00	32	80.00	2	3.00	5	60	8	80	30	90		—		—	1	25	—	—			2	6.00
17	1	6.00	1	3.33	4	13.00	2	5.00	32	80.00	2	3.00	5	60	6	60	36	1.08				—	1	25	—				2	6.00
18	1	6.00	1	3.33	4	13.00	2	5.00	31	77.50	2	3.00	5	60	7	70	45	1.35	14	91			1	25					2	6.00
19	1	6.00	1	3.33	4	13.00	2	5.00	30	75.00	2	3.00	5	60	7	70	36	1.08			—		1	25	14	$1.05			2	6.00
20	1	6.00	1	3.33	3	9.75	2	5.00	30	[illegible]	2	3.00	4	48	7	70	43	1.29	—	—			1	25		—			2	6.00
21	1	6.00	1	3.33	4	13.00	2	5.00	20	62.50	1	1.50	2	24	4	40			—	—		—	1	25	—	—			—	—
		180.00		99.90		293.50		142.00		1,809.49		55.50		16.80		19.[illegible]0		31.20		5.83		2.52		10.02		1.05		63.27		115.50

Date 1882	Firemen Hours	Firemen Amount	Coal Passers Hours	Coal Passers Amount	Coal for Boilers Tons	Coal for Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Lbs	Tallow Amount	Waste Lbs	Waste Amount	Coal Oil Pints	Coal Oil Amount	Totals for each Day	Feet sunk each Day	Material	Cameron Pumps Hours run	Cameron Pumps Strokes	Revolutions of Air Pumps	Remarks
Nov. 22	18	$3.60	18	$3.24	1.65	$15.50	3	$0.07			2	$0.16	3	$0.30	3	$0.06	$88.04	—		—			Caisson built at 100' 30. Sand pumps tried. Blew off hose connections.
23	24	4.80	24	4.32	11.[illegible]5	40.50	3	07			3	24	4	40	3	06	138.71	0.00					
24	24	4.80	24	4.32	10.87	36.25	3	07	—	—	3	24	4	40	3	06	137.53	2.07		16			
25	24	4.80	24	4.32	13.80	46.00	3	07	—	—	2	16	4	40	3	06	[illegible]	1.67	Fine river sand, &c.	16		—	Anchor ice choked suctions to Camerons
26	48	9.00	24	4.32	16.35	54.50	3	07			3	24	4	40	3	06	15[illegible].98	4.04		24		—	
27	48	9.60	24	4.32	16.05	53.50	3	07			3	24	4	40	3	06	158.04	5.90		24			
28	48	9.60	24	4.32	14.32	47.75	3	07	3	$0.37	3	24	4	40		12	[illegible]	3.18		24			
29	48	9.60	24	4.32	8.62	43.12	3	07	3	38	3	24	4	40	6	12	140.39	4.95		24			
30	48	9.60	24	4.32	7.50	37.50	3	07	3	37	3	24	4	40	6	12	141.15	4.37		22			
Dec. 1	48	9.60	24	4.32	[illegible]	35.62	3	07	3	38	—	—	4	40	6	12	140.25	0.25	Blue Clay	19		—	
2	48	9.60	24	4.32	10.05	50.25	3	07	3	37	3	24	4	40	6	12	151.16	1.05	Stiff mixed with blue clay and soft, harder clay, stones, &c.	20		—	
3	48	9.60	24	4.32	13.15	48.60	3	07	3	38	3	24	4	40	6	12	[illegible]	1.40		18			
4	48	9.60	24	4.32	10.05	33.50	3	07	3	37	3	24	4	40	6	12	138.0[illegible]	2.21		24			
5	48	9.60	24	4.32	12.5[illegible]	41.75	3	07	3	38	3	24	4	40	6	12	[illegible]	2.17		23		—	
6	48	9.60	24	4.32	12.45	41.50	3	07	3	37	3	24	4	40	6	12	136.82	1.97		[illegible]		—	
7	48	9.60	24	4.32	11.25	37.50	3	07	3	38	4	32	4	40	6	12	[illegible]	0.70		21		—	
8	48	9.60	24	4.32	12.52	[illegible]	3	07		25	4	32	4	40	6	12	[illegible]	1.55		22½		—	
9	48	9.60	24	4.32	14.85	49.50	3	07	2	25	4	32	4	40	6	12	[illegible]	0.41		23		—	
10	48	9.60	24	4.32	15.5[illegible]	51.75	3	07	2	25	4	32	4	40	6	12	159.89	[illegible]	Sand with some clay and silt	23			
11	48	9.60	24	4.32	14.62	48.75	3	07	2	25	4	32	4	40	6	12	158.04	[illegible]		21			
12	48	9.60	24	4.32	17.47	58.25	3	07	2	25	4	32	4	40	6	13	158.30	2.38		24			
13	48	9.60	24	4.32	[illegible]	54.50	3	07	2	25	4	32	4	40	6	12	[illegible]	2.17		23			
14	48	9.60	24	4.32	16.87	56.25	3	07	2	25	4	32	4	40	6	12	158.01	[illegible]		24		10	[gravel at 4 P.M.
15	48	9.60	24	4.32	10.87	36.25	3	07	2	25	4	32	4	40	6	12	[illegible]	[illegible]	Sand cemented gravel, and some clay.	15		48	Commenced sacking out
16	48	9.60	24	4.32	5.55	18.50	3	07	2	25	2	16	3	30	6	12	152.30	0.50		—		40	Struck rock.
17	48	9.60	24	4.32	[illegible]	[illegible]	3	07	2	25	3	24	4	40	[illegible]	12	[illegible]	0					
18	48	9.60	24	4.32	5.70	19.00	3	07	2	25	3	24	4	40	6	12	151.04	0.32				38	Cutting edge at 95.99.
19	48	9.60	24	4.32	[illegible]	20.75	2	05	2	25	2	16	2	20	6	12	150.40	—		—		—	
20	48	9.60	24	4.32	4.87	16.25	2	05	2	25	2	16	2	20	6	12	140.50	—		—		—	
21	—	—	—	—	—	—	—	—	—	—	—	—					[illegible]			—			
		258.00		[illegible]		1,153.59		1.99		7.00		7.04		11.00		3.12	4,451.97						

Time of Nos. I and III Locks and Pumps

Time of running Cameron pumps not kept accurately.

Generally about 36 strokes forward and return per minute.

APPENDIX F.—Continued.

TIME, COST, AND MATERIALS USED IN FOUNDATION OF PIER III.

Date, 1883.	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub-Foremen Days	Sub-Foremen Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Hours	Pressure Men Amount	Coffee-house Men Days	Coffee-house Men Amount	Coffee Lbs.	Coffee Amount	Sugar Lbs.	Sugar Amount	Candles No.	Candles Amount	Red Lead Lbs.	Red Lead Amount	Wick Lbs.	Wick Amount
Jan. 6	1	$6.00	1	$3.33	2	$6.00	2	$4.50	155	$43.59	2	$3.00	1	$0.12	2	$0.20		—	—			—
7	1	6.00	1	3.33	3	9.00	2	4.50	108	24.30	2	3.00	1	12	2	20	—	—		—	—	
8	1	6.60	1	3.33	3	9.00	2	4.50	190	42.75	2	3.00	1	12	2	20				—		
9	1	6.00	1	3.33	3	9.00	2	4.50	176	39.60	2	3.00	2	24	2	20		—	—			—
10	1	6.00	1	3.33	2	6.00	2	4.50	97	21.82	2	3.00	2	.24	3	30	6	$0.18	5	$0.32	1	$0.21
11	1	6.00	1	3.33	2½	7.50	2	4.50	235	59.90	2	3.00	3½	42	4	40	25	75	2	11	½	10
12	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	3	36	6½	.65	36	1.08	—	—	—	—
13	1	6.00	1	3.33	3	9.00	2	4.50	176	49.50	2	3.00	3	36	6½	65	30	90		—		
14	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	3½	42	6	60	30	90	5	32	1	21
15	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	2½	.30	5	50	6	18		—	—	
16	1	6.00	1	3.33	3	9.00	2	4.50	184	51.75	2	3.00	2½	30	5	50	18	54				
17	1	6.00	1	3.33	2	6.00	2	4.50	146	41.06	2	3.00	1½	18	3	30	18	54	—			—
18	1	6.00	1	3.33	2	6.00	2	4.50	168	47.25	2	3.00	2	24	4½	45	6	18		—	—	
19	1	6.00	1	3.33	3	9.00	2	4.50	144	40.50	2	3.00	2	24	4	40	—		—			—
20	1	6.00	1	3.33	2	6.00	2	4.50	104	29.25	2	3.00	1½	18	2½	25	3	09	—		—	—
21	1	6.00	1	3.33	3	9.00	2	4.50	48	13.50	2	3.00	1½	18	2½	25	3	09		—	—	
22	1	6.00	1	3.33	3	9.00	2	4.50	64	18.00	2	3.00	1	12	3	30	3	09	—			—
23	1	6.00	1	3.33	3	9.00	2	4.50	136	38.25	2	3.00	2	.24	4	40	33	.99		—	—	
24	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	2½	.30	4	40	33	99	5	32	1	21
25	1	6.00	1	3.33	3	9.00	2	4.50	192	54.00	2	3.00	3	.36	5	.50	36	1.08	—			—
26	1	6.00	1	3.33	3	9.75	2	5.00	240	75.00	2	3.00	3½	.42	6½	.65	42	1.26		—	—	
27	1	6.00		—	3	9.75	2	5.00	236	73.75	2	3.00	3½	42	6½	65	42	1.26				
28	1	6.00	1	3.25	3	9.75	2	5.00	232	72.50	2	3.00	3½	42	4	40	36	1.08	—			—
29	1	6.00		3.25	3	9.75	2	5.00	240	75.00	2	3.00	4½	54	4	40	36	1.08		—	—	
30	1	6.00	1	3.25	3	9.75	2	5.00	232	72.50	2	3.00	2	24	7½	.75	42	1.26	—			—
31	1	6.00	1	3.25	3	9.75	2	5.00	224	70.00	2	3.00	3½	42	6	.60	36	1.08	—	—	—	—
Feb. 1	1	6.00	1	3.57	3	9.75	2	5.00	168	62.50	2	3.00	4	48	6	60	36	1.08	5	32	1	21
2	1	6.00	1	3.57	4	13.00	2	5.00	180	75.00	2	3.00	3½	42	7	.70	48	1.44		—		
3	1	6.00	1	3.57	4	13.00	2	5.00	168	70.00	2	3.00	2½	30	6½	.65	42	1.26	—			—
4	1	6.00	1	3.57	4	13.00	2	5.00	156	65.00	2	3.00	4	48	7½	75	42	1.26		—	—	—
5	1	6.00	1	3.57	4	13.00	2	5.00	162	67.50	2	3.00	4	48	4	.40	48	1.44	—			
6	1	6.00	1	3.57	4	13.00	2	5.00	168	70.00	2	3.00	4	.48	5	50	48	1.44			—	—
7	1	6.00	1	3.57	4	13.00	2	5.00	174	72.50	2	3.00	4	48	4½	45	60	1.80		—	5	
8	1	6.00	1	3.57	4	13.00	2	5.00	192	80.00	2	3.00	2½	30	6	60	54	1.62	—	—		
9	1	6.00	1	3.57	5	16.25	2	5.00	231	96.25	2	3.00	3	.36	4½	.45	42	1.26				—
10	1	6.00	1	3.57	4	13.00	2	5.00	192	80.00	2	3.00	2½	30	5	50	44	1.32		—	—	
11	1	6.00	1	3.57	4	13.00	2	5.00	189	78.75	2	3.00	4	.48	5	.50	32	96	—	—		—
12	1	6.00	1	3.57	4	13.00	2	5.00	144	60.00	2	3.00	4½	54	7½	.75	54	1.62				—
13	1	6.00	1	3.57	4	13.00	2	5.00	180	75.00	2	3.00	4	48	5	50	54	1.62	—	—	—	
14	1	6.00	1	3.57	4	13.00	2	5.00	180	75.00	2	3.00	4	48	7½	.75	48	1.44	—			
15	½	1.50	½	1.79	2	6.50	½	1.25	84	35.00	½	.75	½	.06	1	10	18	54				—
																			70	4.55	—	1.05
		241.50		134.70		410.50		191.25		2,325.52		120.75		13.02		19.40		35.70		5.94		1.99

Date, 1883.	Coal for Heating No. of Boxes	Coal for Heating Amount	Linseed Oil Gals.	Linseed Oil Amount	Sacking out Material Hours	Sacking out Material Amount	Day Engineer Days	Day Engineer Amount	Night Engineer Days	Night Engineer Amount	Firemen Hours	Firemen Amount	Coal Passers Hours	Coal Passers Amount	Coal for Boilers Tons	Coal for Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Pints	Tallow Amount	Waste Lbs.	Waste Amount	Coal Oil Pints	Coal Oil Amount
Jan. 6	1½	$0.75		—	—	—	—	—						—	—			—				—	—	—	—	—
7	1½	.75	—	—	—	—	—	—	—	—	—	—	—	—		—	—			—	—	—		—	—	
8	1½	.75		—	—	—		—		—									—	—					—	
9	1½	.75		—	—	—	—		—		—			—				—							—	—
10	1½	75	—	—	—	—	1	$3.33	2	$6.00	21	$4.80	24	$4.32	.5	[illegible]	3	$0.07	2	$0.25	2	$0.16	2	$0.20	6	$0.12
11	1½	75	—	—	—	—	1	3.33	2	6.00	24	4.80	24	4.32	6.5	32.50	3	.07	3	38	3	24	2	20	6	12
12	1½	75	—	—	—	—	—		2	6.00	24	4.80	24	4.32	13.5	67.50	3	.07	3	37	3	24	2	20	6	12
13	1½	75	—	—	—	—			2	6.00	24	4.80	24	4.32	13.7	68.50	3	07	3	.37	4	.32	2	20	6	12
14	1½	.75	—	—	—	—	—	—	2	6.00	24	4.80	24	4.32	12.5	62.50	3	07	3	37	4	.32	2	20	6	12
15	1½	.75	—	—	—	—	—	—	2	6.00	24	4.80	24	4.32	8.3	41.50	3	07	3	.37	3	24	2	20	6	12
16	1½	75	—	—	—	—			2	6.00	24	4.80	24	4.32	9.0	45.00	3	.07	2	25	2	16	2	20	6	12
17	1½	75	—	—	—	—		—	2	6.00	24	4.80	24	4.32	9.0	45.00	3	07	3	38	3	24	2	20	6	12
18	1½	75	—	—	—	—	—		2	6.00	24	4.80	24	4.32	8.0	40.00	3	.07	3	.38	2	16	2	20	6	12
19	1½	75	—	—	—	—			2	6.00	24	4.80	24	4.32	6.0	30.00	2	.05	2	.25	2	16	2	20	6	12
20	1½	.75	—	—	—	—		—	2	6.00	24	4.80	24	4.32	5.8	29.00	2	05	2	.25	2	16	2	20	6	12
21	1½	75	—	—	—	—	—	—	2	6.00	24	4.80	24	4.32	6.0	30.00	2	.05	2	.25	2	16	2	20	6	12
22	1½	75	—	—	—	—			2	6.00	24	4.80	24	4.32	6.0	30.00	2	05	2	25	2	16	2	20	6	12
23	1½	75	—	—	—	—		—	2	6.00	24	4.80	24	4.32	10.0	50.00	3	07	3	38	3	24	2	20	6	12
24	1½	75	—	—	—	—	1	3.23	2	6.00	24	4.80	24	4.32	11.0	55.00	3	07	3	37	3	24	2	20	6	12
25	1½	75	—	—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	10.8	54.00	3	07	3	38	3	24	2	20	6	12
26	1½	.75	—	—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	9.0	45.00	3	07	3	37	3	24	2	20	6	12
27	1½	75	—	—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	8.0	40.00	3	07	3	.38	3	24	2	20	6	12
28	1½	75		—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	8.0	40.00	3	07	3	37	3	24	2	20	6	12
29	1½	.75		—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	7.5	37.50	3	07	3	35	3	24	2	20	6	12
30	1½	75	—	—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	8.0	40.00	3	07	3	.37	3	24	2	20	6	12
31	1½	.75		—	—	—	1	3.23	2	6.00	24	4.80	36	6.48	6.0	30.00	3	.07	3	38	3	24	2	20	6	12
Feb. 1	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	36	6.48	7.6	38.00	3	.07	3	.37	3	24	2	20	6	12
2	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	36	6.48	7.1	35.50	3	.07	3	38	3	24	2	20	6	12
3	1½	75	—	—	—	—	1	3.57	2	6.42	24	4.80	36	6.48	7.2	36.00	3	07	3	.37	3	24	2	20	6	12
4	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	24	4.32	7.0	35.00	3	07	3	38	3	24	2	20	6	12
5	1½	75		—	—	—	1	3.57	2	6.42	24	4.80	24	4.32	8.0	40.00	3	07	3	.37	3	24	2	20	6	12
6	1½	75	—	—	—	—	1	3.57	2	6.42	24	4.80	24	4.32	8.6	43.00	3	.07	3	38	3	24	2	20	6	12
7	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	36	6.48	7.7	38.50	3	07	3	37	3	.24	2	20	6	12
8	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	36	6.48	7.8	39.00	3	.07	3	38	3	.24	2	20	6	12
9	1½	75	—	—	30	$5.25	1	3.57	2	6.42	24	4.80	36	6.48	3.9	19.50	3	.07	3	.37	3	24	2	20	6	12
10	1½	.75		—	65	11.37	1	3.57	2	6.42	24	4.80	36	6.48	4.0	20.00	3	.07	3	.38	2	.16	2	20	6	12
11	1½	.75		—	65	11.37	1	3.57	2	6.42	24	4.80	24	4.32	4.0	20.00	3	.07	2	28	2	.16	2	20	6	12
12	1½	.75	—	—	30	5.25	1	3.57	2	6.42	24	4.80	24	4.32	4.2	21.00	2	.07	2	.25	2	.16	2	20	6	12
13	1½	.75		—	—	—	1	3.57	2	6.42	24	4.80	24	4.32	4.5	22.50	2	07	2	25	2	.16	2	20	6	12
14	1½	75		—	—	—	1	3.57	2	6.42	24	4.80	24	4.32	4.7	23.50	2	07	2	25	2	16	2	20	6	12
15	½	.25	—	—		—							—	—	—	—	—				—			—		—
			2	$1.35																						
		30.25		1.35		33.24		82.48		221.88		172.80		185.76		1,346.35		2.44		12.25		7.84		7.20		4.32

Date, 1883.	Total for each day	Feet sunk each day	Material	Cameron Pumps Hours run	Cameron Pumps Rev. per min.	Revolutions of Air-Pumps	Remarks
							Caisson built at 1010.30.
Jan. 6	$67.40	—	Ice in two layers,	—		—	Cutting ice under caisson.
7	51.20	—	10″–12″ and 7″–18″.	—	—	—	" " " " ½ day.
8	69.05	8.39		—	—	—	Lowering with screws; cutting ice, etc.
9	66.62	1.98	Slush, ice, and sand.	—		—	
10	67.75	0.07		—	—	—	Air put on 5.30 P.M.
11	138.72	1.24		7½	32	—	Started Camerons, 3 P.M.
12	164.04	3.21		17½	28	—	Pumping sand at s. end, & slush ice.
13	162.60	3.98		24	25	25	Pushing out ice nearly all day.
14	159.48	2.22		17	—		
15	136.93	1.03		3	28	30	
16	110.5	4.80	Fine bar sand.	13½	32	—	
17	121.79	4.43		12	36	—	
18	127.75	2.52		10½	35		
19	113.62	0					
20	98.25	0		—		28	
21	86.50	0		—	—	20	
22	90.99	0		—		24	
23	132.59	2.72	Clay, s. w. corner.	16½		25	
24	157.15	0		21	33	36	
25	158.04	2.67		24	35	38	
26	171.67	0		22½	36	35	Feed-water heater in use after 1 P.M., Jan. 26th.
27	162.10	2.37		24	35	—	
28	163.66	0		24			
29	163.79	2.54		23	35	25	
30	164.01	0	Silt and blue clay.	24	—	26	
31	151.37	2.49		23½	34	26	
Feb. 1	153.53	0		22½	—		
2	166.66	2.47		24	—		
3	161.80	0		24	34	24	
4	153.93	2.99	Lignite, sand, and some gravel.	21½	38	28	
5	161.25	0		23½	35	37	
6	166.86	2.22		20½	34	40	
7	167.32	45		24	34	—	
8	175.12	36	Gravel and boulders.	23½	36		
9	179.9	0		4½	36	24	Camerons stopped at 4.40 A.M.
10	167.01	10				22	Sacking out gravel.
11	173.29	11		—	—		" "
12	140.39	28					Began concreting at 3 P.M.
13	151.33	0					
14	152.40	01		—	—	—	Cutting edge at 954.14
15	47.84	—		—			Finished lock-shaft 12.40 A.M.
	6.95						
	5,609.03			495⅛			

APPENDIX F. — CONTINUED.

TIME, COST, AND MATERIALS USED IN FOUNDATION FOR PIER IV.

Date 1883	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub Foremen Days	Sub Foremen Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Hours	Pressure Men Amount	Coffee House Men Days	Coffee House Men Amount	Coffee Lbs	Coffee Amount	Sugar Lbs	Sugar Amount	Candles No.	Candles Amount	Red Lead Lbs	Red Lead Amount	Wick Lbs	Wick Amount
Mar																						
17	—	—	1	$3.33	4	$12.00	1	$2.25	24¼	$54.56	2	$3.00	2	$0.25	3	$0.30	18	$0.63		—	—	
18	—	·	1	3.33	4	12.00	2	4.50	27	60.75	2	3.00	3½	44	8	80	30	1.05	—		—	
19	—		1	3.33	3	9.00	2	4.50	30	67.50	2	3.00	4½	56	6	60	18	63	—	—		—
20	½	$3.00	1	3.23	4	12.00	2	4.50	32	72.00	2	3.00	5	62	8	80	22	77		—		—
21	1	6.00		—	4	12.00	2	4.50	31	69.75	2	3.00	5	63	8	80	36	1.26		—		—
22	1	6.00	1	3.22	3	9.00	2	4.50	32	72.00	2	3.00	3½	44	5	50	30	1.05	5	$0.31	2	$0.42
23	1	6.00	1	3.23	3	9.00	2	4.50	31	69.75	2	3.00	4	50	5	50	30	1.26			—	
24	1	6.00		3.22	3	9.00	2	4.50	30	67.50	2	3.00	4	50	4	40	24	84				—
25	1	6.00	1	3.22	3	9.00	2	4.50	17½	39.37	2	3.00	1	17	5	50	20	70	—	—		—
26	1	6.00	1	3.23	2	6.00	2	4.50	19	42.75	2	3.00	2	33	4	40	12	42	—	—		—
27	1	6.00	1	3.23	2	6.00	2	4.50	15	33.75	2	3.00	1½	25	4	40	26	91	—	—	—	—
28	1	6.00	1	3.22	3	9.00	2	4.50	30	67.50	2	3.00	2	33	5	50	42	1.47			—	
29	1	6.00		3.23	3	9.00	2	4.50	30	67.50	2	3.00	3	37	5	50	30	1.05			—	
30	1	6.00	1	3.22	3	9.00	2	4.50	28	63.00	2	3.00	4	50	6	60	24	84				—
31	1	6.00	1	3.23	3	9.00	2	4.50	25	56.25	2	3.00	3	37	4	40	30	1.05		—		—
Apr																						
1	1	6.00	1	3.33	3	9.00	2	4.50	29	65.25	2	3.00	4	50	5	50	30	1.05	—		—	
2	1	6.00	1	3.33	3	9.00	2	4.50	28	63.00	2	3.00	3½	44	5	50	24	84			—	—
3	1	6.00	1	3.34	3	9.00	2	4.50	26	58.50	2	3.00	2	25	5	50	30	1.05		—		—
4	1	6.00	1	3.33	3	9.00	2	4.50	23½	52.87	2	3.00	2½	31	5	50	24	84	—	—		—
5	1	6.00	1	3.34	3	9.75	2	5.00	25	62.50	2	3.00	3½	43	4	40	24	84	—	—		—
6	1	6.00	1	3.33	3	9.75	2	5.00	27	67.50	2	3.00	3½	43	4	40	30	1.05		—		—
7	1	6.00	1	3.33	3	9.75	2	5.00	27	67.50	2	3.00	2½	31	4	40	36	1.26	5	32	2	42
8	1	6.00	1	3.34	3	9.75	2	5.00	25½	63.75	2	3.00	3	37	4	40	36	1.26			—	
9	1	6.00	1	3.33	3	9.75	2	5.00	27	67.50	2	3.00	3½	43	4	40	24	84				—
10	1	6.00	1	3.33	4	13.00	2	5.00	31	77.50	2	3.00	3½	43	5	50	[illegible]	[illegible]		—		—
11	1	6.00	1	3.33	4	13.00	2	5.00	32	80.00	2	3.00	4	50	6½	65	36	1.26	—	—		
12	1	6.00	1	3.33	4	13.00	2	5.00	31½	78.75	2	3.00	4	50	7	70	30	1.05	—	—		
13	1	6.00	1	3.34	1	3.00	2	5.00	31	77.50	2	3.00	4	50	7	70	36	1.26		—	—	
14	1	6.00	1	3.33	4	13.00	2	5.00	25	62.50	2	3.00	5	62	7	70	48	1.68			—	—
15	1	6.00	1	3.33	4	13.00	2	5.00	25½	63.75	2	3.00	4½	57	6	60	54	1.89				—
16	1	6.00	1	3.34	4	13.00	2	5.00	32	80.00	2	3.00	4	50	6	60	51	1.78	—	—		—
17	1	6.00	1	3.33	4	13.00	2	5.00	32	80.00	2	3.00	4½	56	8	80	45	1.57	—	—		
18	1	6.00	1	3.33	4	13.00	2	5.00	31	77.50	2	3.00	6½	81	8	80	48	1.68	—	—		
19	1	6.00	1	3.34	4	13.00	2	5.00	31	77.50	2	3.00	5	62	7	70	30	1.05	—			
20	1	6.00	—	—	2	6.50	1	2.50	15	37.50	2	3.00	1	13	2	20		—			—	
		189.00		108.49		307.25		160.75		1264.80		105.00		15.47		18.95		34.41		64		81

Date 1883	Coal for Heating Boxes	Coal for Heating Amount	Linseed Oil Gals	Linseed Oil Amount	Sacking Material Days	Sacking Material Amount	Day Engineer Days	Day Engineer Amount	Night Engineer Days	Night Engineer Amount	Firemen Hours	Firemen Amount	Coal Passers Hours	Coal Passers Amount	Coal for Boilers Tons	Coal for Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Pints	Tallow Amount	Waste Lbs	Waste Amount	Coal Oil Pints	Coal Oil Amount
Mar																										
17	1	$0.50		—			1	$3.33	1	$2.90	24	$4.80	36	$6.48	4.9	$24.50	3	$0.07	3	$0.38	3	$0.24	2	$0.20	6	$0.12
18	1	50				—	1	3.23	1	2.90	24	4.80	24	4.32	6.0	30.00	3	07	3	37	3	24	2	20	6	12
19	1	50	—	—		—	1	3.23	1	2.90	21	[illegible]	24	4.32	6.5	32.50	3	07	3	38	3	24	2	20	6	12
20	1	50	—	—	—	—	1	3.22	1	2.90	24	4.80	24	4.32	4.5	22.50	3	07	3	38	3	24	2	20	6	12
21	1	50			—	—	1	3.23	1	2.90	24	4.80	24	4.32	7.0	35.00	3	07	3	37	3	24	2	20	6	12
22	1	50	¼	$0.18	—	—	1	3.32	1	2.90	24	4.80	24	4.32	6.6	33.00	3	07	3	38	3	24	2	20	6	12
23	1	50					1	3.23	1	2.90	24	4.80	24	4.32	7.2	36.00	3	07	3	[illegible]	3	24	2	20	6	12
24	1	50		—		—	1	3.22	1	2.90	36	7.20	24	4.32	4.7	23.50	3	07	3	38	3	24	2	20	6	12
25	1	50	—	—	—	—	1	3.22	1	2.90	36	7.20	24	4.32	5.9	29.50	3	07	3	37	3	[illegible]	2	20		12
26	1	50	—	—	—	—	1	3.23	1	2.90	36	7.20	24	4.32	3.6	18.00	3	07	3	38	3	24	2	20	6	12
27	1	50			7½	$13.12	1	3.23	1	2.90	36	7.20	24	4.32	1.5	7.50	3	07	3	37	2	16	2	20	6	12
28	1	50			15	26.25	1	3.23	1	2.90	36	7.20	24	4.32	[illegible]	11.50	[illegible]	05	3	38	2	16	2	20	6	12
29	1	50		—	7½	13.13	1	3.23	1	2.90	30	6.00	24	4.32	5.1	25.50	3	07	3	37	3	24	2	20	6	12
30	1	50		—		—	1	3.22	1	2.90	24	4.80	24	4.32	6.0	30.00	3	07	3	38	3	24	2	20	6	12
31	1	40	—	—	—	—	1	3.23	1	2.90	24	4.80	24	4.32	6.0	30.00	3	07	3	37	3	24	2	20	6	12
Apr																										
1	1	40					1	3.33	1	3.00	24	4.80	24	4.32	5.7	28.50	3	07	3	38	3	24	2	20	6	12
2	1	40					1	3.33	1	3.00	24	4.80	24	4.32	6.0	30.00	3	07	3	37	3	24	2	20	6	12
3	1	40	—	—	—	—	1	3.33	1	3.00	24	4.80	24	4.32	5.9	29.50	3	07	3	38	3	24	2	20	6	12
4	1	40	—	—	—	—	1	3.34	1	3.00	24	4.80	24	4.32	6.9	34.50	3	07	3	37	3	24	2	20	6	12
5	1	40	—	—	—	—	1	3.33	1	3.00	24	4.80	24	4.32	[illegible]	32.00	3	07	3	37	3	24	2	20	6	12
6	1	40	—				1	3.33	1	3.00	24	4.80	24	4.32	6.5	32.50	3	07	3	37	3	24	2	20	6	12
7	1	40	¼	18		—	1	3.34	1	3.00	24	4.80	24	4.32	6.8	34.00	3	07	3	38	3	24	2	20	6	12
8	1	40			—	—	1	3.33	1	3.00	24	4.80	24	4.32	6.8	34.00	3	07	3	38	3	24	2	20	6	12
9	1	40		—	—	—	1	3.34	1	3.00	24	4.80	24	4.32	6.8	34.00	3	07	3	38	3	24	2	20		12
10	—	—		—	—	—	1	3.33	1	3.00	24	4.80	24	4.32	6.9	34.50	3	07	3	[illegible]	3	24	2	20	6	12
11	1	40	—			—	1	3.33	1	3.00	24	4.80	24	4.32	5.9	29.50	3	07	3	37	3	24	2	20		12
12	1	40	—		—		1	3.34	1	3.00	24	4.80	24	4.32	6.9	34.50	3	[illegible]	3	38	3	24	2	20	6	12
13	—	—					1	3.33	1	3.00	24	4.80	24	4.32	5.6	28.00	3	07	3	37	3	24	2	20	6	12
14	1	50		—	—	—	1	3.33		3.00	24	4.80	24	4.32	[illegible]	20.50	3	07	3	38	3	24	2	20	6	12
15	1	50	—	—	—	—	1	3.34	1	3.00	24	4.80	24	4.32	5.0	25.00	3	07	3	37	3	24	2	20	6	12
16	—	—	—	—	—	—	1	3.33	1	3.00	24	4.80	24	4.32	4.0	20.00	3	07	3	38	3	24	2	20	6	12
17	1	50	—			—	1	3.33	1	3.00	24	4.80	24	4.32	4.0	20.00	3	07	3	37	3	24	2	20	6	12
18							1	3.34	1	3.00	24	4.80	24	4.32	3.1	15.50	3	07	3	38	3	24	2	20	6	12
19	1	50			—	—	1	3.33	1	3.00	24	4.80	24	4.32	[illegible]	7.50	3	07	3	37	3	24	2	20	2	04
20				—	—	—		3.33	—		24	4.80	12	2.16		—	2	05			2	16	2	20	3	06
		13.80		30		52.50		115.04		100.50		[illegible]8.20		151.20		[illegible]		2.41		12.75		8.16		7.00		4.06

Date 1883	Totals for each Day	Feet sunk each Day	Material	Cameron Pumps Hours run	Remarks
Mar					
17	$119.63	—	Yellow clay	3	
18	[illegible]	—		2[illegible]	
19	[illegible]8.27	1.28		8¼	
20	139.1[illegible]	0.74	Blue clay	19[illegible]	
21	149.60	1.85	with small	23½	
22	150.38	1.78	streaks of	24¼	
23	150.40	2.24	sand	23[illegible]	
24	1[illegible].01	1.08		[illegible]	
25	115.10	1.92		9¼	
26	103.79	0.37	[north end	10¼	
27	97.73	2.07	Some sand at	—	Suctions broken
28	157.32		Nearly all sand	—	Sacking out material
29	15[illegible].73		Sand	10¼	Sacking out sand
30	137.41		—	18¾	
31	130.45	—		14¾	
Apr					
1	138.49		Sand with some trash, sticks, &c	22¾	Moved pumps
2	137.4[illegible]	—		22[illegible]	
3	132.50	—	Lignite	23	
4	13[illegible].71		Sand	[illegible]	
5	140.[illegible]		—	23	
6	145.81	—	Sand & gravel	24	
7	148.34	—		22¾	
8	1[illegible]3.73		Sand	[illegible]	
9	147.17		—	22[illegible]	
10	160.[illegible]		—	24	
11	159.09	—	—	16	Moved pump 23′ 25 back.
12	162.71	—		23[illegible]	
13	154.75	—		22[illegible]	
14	133.79			9¼	
15	135.10		—	5[illegible]	
16	149.68	—	—	1	
17	150.21				
18	143.09				
19	13[illegible].58				
20	[illegible]0.59				
	[illegible]			501[illegible]	

APPENDIX G.

SPECIFICATIONS FOR SUPERSTRUCTURE.

GENERAL DESCRIPTION.

THERE will be three spans of through bridge, each 330 feet long between centers, divided into fifteen panels of 22 feet each, and two spans of deck bridge, each 110 feet long, divided into five panels.

In the through spans, the top chord, the end posts, the nine central panels of the bottom chord, the bolsters, rollers, and bearing plates, and all pins of every description, will be of steel; the other parts will be of wrought iron, except the pedestal castings and portal ornaments, which will be of cast iron. The deck spans will be entirely of wrought iron, except the pins, rollers, and bearing plates, which will be of steel, and the pedestal castings

Each through span will contain approximately 492,000 pounds of wrought iron, and 288,000 pounds of steel, of which 78,000 pounds will be steel eye bars. Each deck span will contain approximately 120,000 pounds of wrought iron.

PLANS

Full detail plans, showing all dimensions, will be furnished by the Chief Engineer of the Missouri Valley and Blair Railway and Bridge Company. The work shall be built in all respects according to these plans. No allowance will be made to the Contractor for any fittings of parts during erection, nor for any changes necessitated by errors in the plans when these errors could be discovered by inspection of the plans.

The dimensions given for rivets on plans are the diameter of the rivet before driving, the rivet holes to be $\frac{1}{16}$ of an inch larger than this diameter.

MATERIALS.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed full access to any of the works in which any portion of the materials are made. Timely notice shall be given to the Engineer, so that his inspectors may be on hand.

The steel shall be manufactured by the open hearth process; Bessemer steel will not be accepted. A small ingot shall be cast from every charge, and from this ingot a sample bar $\frac{3}{4}$ of an inch in diameter shall be rolled; if this bar fails to meet the requirements of the laboratory tests, the whole charge shall be rejected.

Steel used in the compression members, bolsters, bearing plates, pins, and rollers shall contain not less than $\frac{34}{100}$ nor more than $\frac{42}{100}$ of one per cent. of carbon, and less than $\frac{1}{10}$ of one per cent. of phosphorus. A sample test bar $\frac{3}{4}$ of an inch in diameter shall bend 180° around its own diameter without sign of crack or flaw. The same bar tested in a lever machine shall show an elastic limit of not less than 50,000 pounds, and an ultimate strength of not less than 80,000 pounds per square inch; it shall elongate at least 15 per cent. in a length of 8 inches before breaking, and shall have a reduced area of 35 per cent. at the point of fracture. It shall be incapable of tempering.

Steel for rivets and eye-bars shall contain not more than $\frac{25}{100}$ of one per cent. of carbon, and less than $\frac{1}{10}$ of one per cent. of phosphorus. A sample bar $\frac{3}{4}$ of an inch in diameter shall bend 180° and be set back upon itself without showing crack or flaw; when tested in a lever machine it shall have an elastic limit of not less than 40,000 pounds, and an ultimate strength of not less than 70,000 pounds per square inch; it shall elongate at least 18 per cent. in a length of 8 inches, and shall show a reduction of at least 45 per cent. at the point of fracture. In full sized bars this steel shall have an elastic limit of at least 35,000 pounds, and an ultimate strength of at least 65,000 pounds per square inch; it shall elongate 10 per cent. before breaking, and for strains less than 30,000 pounds per square inch shall show a modulus of elasticity between 28,000,000 and 30,000,000 pounds.

Facilities for testing the sample bars shall be furnished by the Contractor at a point convenient to the steel works, and the tests shall be made at the expense of the Contractor and under the direction of the Chief Engineer.

The steel plates for the chords and end posts shall be rolled in a universal mill.

Steel for pins shall not be hammered, but rolled between gothic rolls.

The iron used in tension members shall be double refined iron, rolled twice from the puddled bar. Small samples having a minimum length of 8 inches shall be furnished by the Contractor for testing as directed by the Engineer; these samples shall show an elastic limit of at least 26,000 pounds, and an ultimate strength of at least 50,000 pounds per square inch; shall elongate at least 15 per cent., and shall show a reduced area of at least 25 per cent. at the point of fracture. The fracture shall be of uniform fibrous character, free from crystalline appearance. When tests are made of full-sized bars, a reduction of from 5 to 10 per cent., according to size of bar, from these requirements will be allowed, provided the iron is of uniform and fibrous character.

Small samples having a minimum length of 8 inches shall be furnished by the Contractor from the iron used in shapes, plates, and other miscellaneous forms, as directed by the Engineer, these samples shall show an elastic limit of at least 24,000 pounds, and an ultimate strength of at least 47,000 pounds per square inch, shall elongate at least 10 per cent. before breaking, and show a reduction of area of at least 15 per cent. at the point of fracture. In plates more than 30 inches wide an elongation of 8 per cent. and a reduction of 12 per cent. at the point of fracture will be considered satisfactory.

Cast iron shall be of the best quality of tough, gray iron.

RIVETED WORK.

The riveted steel work used shall be punched with holes not larger than $\frac{13}{16}$ of an inch in diameter; the several parts of each member shall then be assembled, and the holes shall be reamed to $\frac{15}{16}$ of an inch in diameter, at least $\frac{1}{16}$ of an inch being taken out all around; the sharp edge of the reamed hole shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. All rivets in steel members shall be of steel; they shall be of such size that they will fill the hole before driving, and, whenever possible, shall be driven by power. All bearing surfaces shall be truly faced. The chord pieces shall be fitted together in the shop, in lengths of at least five panels, and marked; when so fitted, there shall be no perceptible wind in the length laid out. The pin holes shall be bored truly, so as to be equally distant, parallel with one another and at right angles to the axis of the member.

All wrought-iron work shall be punched accurately with holes $\frac{1}{16}$ of an inch larger than the size of the rivet, and when put together a cold rivet shall pass through every hole without reaming. So far as possible, all rivets shall be driven by power. The holes for the rivets connecting the floor beams with the posts, and with the bolsters, which must be driven after erection, shall be accurately drilled to a templet; these holes shall be 1 inch in diameter, and the rivets $\frac{7}{8}$ of an inch in diameter before driving. The pin holes in the vertical post shall be truly parallel with one another, and at right angles to the axis of the post.

Power riveters shall be direct acting machines worked by steam, hydraulic pressure, or compressed air, and capable of holding on to the rivet when the upsetting is completed. Cam riveters will not be allowed.

All plates, angles, and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workmanlike manner. Surfaces in contact shall be painted before they are put together.

APPENDIX G. CONTINUED.

FORGED WORK.

The heads of iron eye-bars, and the enlarged ends of screws in laterals and counters shall be formed by upsetting, or by die-forging with a plate welded on the side; welds in the body of the bar will not be allowed. Six extra iron eye-bars, of such size as the Engineer shall direct, shall be furnished by the Contractor to be tested; these test bars shall meet the requirements above specified for strength of material, and at least four of them shall break in the body of the bar. Should these test bars fail to meet the requirements of the specifications, the whole lot of bars may be rejected.

The heads of steel eye-bars shall be formed by upsetting and forging into shape, or by such other process as may be accepted by the Engineer; no welds will be allowed. After the working is completed, the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. Four sample bars of sizes required in the work shall first be manufactured by the Contractor, and tested under the direction of the Engineer; these bars shall meet the requirements above specified, and at least three of them shall break in the body of the bar. If the tests of these four bars are satisfactory, the Contractor shall proceed with the manufacture of the full order of steel bars for the work, and from the bars so manufactured the inspector shall from time to time select six bars to be tested to breaking, which bars shall also conform to the requirements of the specifications. Should these test bars fail to meet the requirements of the specifications, the whole lot of bars may be rejected. All steel bars shall be tested to a strain of 20,000 pounds per square inch before shipment.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a rotary facer. All surfaces so designated on the plans shall be planed.

All pins shall be accurately turned to a gauge, and shall be of full size throughout. The pin holes shall be bored to fit the pins, with a play not exceeding $\frac{1}{50}$ of an inch. These clauses apply to all lateral connections, as well as to those of the main trusses. All pins shall be supplied with pilot nuts for use during erection.

All screws shall have a truncated V thread, United States standard sizes.

MISCELLANEOUS.

All workmanship, whether particularly specified or not, must be of the best kind now in use in first-class bridge work. Flaws, or surface imperfections, or irregular shapes, will be sufficient ground for the rejection of material. Rough and irregularly finished work will not be accepted.

All iron and steel work shall be painted with one coat of Cleveland Iron-Clad Paint (purple brand) mixed with boiled linseed oil before it leaves the shop, excepting machine-finished bearing surfaces, which shall be coated with white lead and tallow.

PROPOSALS.

Proposals will be received for the work in the following manner: —

FIRST. Material: *Steel* per pound; *Wrought Iron* per pound; *Cast Iron* per pound; the prices to include material and all patterns and other work of every description, delivered to the Chicago and North Western Railway on cars in Chicago.

SECOND. A single gross sum for the erection of the entire superstructure exclusive of the lower staging.

THIRD. A single gross sum for furnishing the lower staging for the entire work.

The right is reserved to accept any proposal for material delivered without erection or lower staging, or for material delivered and erected without lower staging. The lower staging will be understood to include everything below the floor timbers, on which the upper staging or the movable traveler will rest. Erection will include setting the wall plates, and drilling the necessary holes for the anchor bolts.

TIME.

The entire material shall be rolled and delivered at the Contractor's shop on or before June 1st, 1883. The manufacture of the first span shall be completed on or before July 1st, 1883, that of the second span on or before August 1st, 1883, and that of the third span on or before September 1st, 1883.

No material shall be shipped until July 1st, 1883, unless by the express direction of the Chief Engineer.

The erection of the first long span shall be begun on or about August 1st, 1883, and the last span shall be erected, ready for the track, on or before November 1st, 1883.

TERMS.

The Missouri Valley and Blair Railway and Bridge Company will pay for the transportation of materials used in the bridge, from Chicago to the bridge site, and will secure to the Contractor the benefit of construction rates for tools and men.

Monthly estimates shall be made at the end of each month of the work done during that month. In these monthly estimates, the material delivered at the Contractor's shop, but not manufactured, shall be estimated at 60 per cent. of the contract price for finished material in Chicago; manufactured material of uncompleted spans, at 80 per cent. of the contract price for finished material in Chicago; and manufactured material for each entirely finished span at 90 per cent. of the contract price for finished material in Chicago. Payments shall be made on or about the 15th day of the following month on these estimates, deducting from the amount of the same 10 per cent. as security, to be held until the completion of the entire contract.

Estimates will not be made upon iron delivered and manufactured unless a proportionate amount of steel has also been delivered and manufactured.

Should the Contractor fail to establish his ability to manufacture steel eye-bars of the character required on or before April 1st, 1883, he will then be required to furnish iron eye-bars of about 40 per cent. larger section, and proportionately larger steel pins, the dimensions and plans of which will be furnished by the Engineer, for the same aggregate price as he would have received for steel eye-bars and pins as shown upon plans.

No material will be paid for which does not form a part of the permanent structure.

If the tests of full sized eye-bars of iron and steel prove satisfactory, the expense of making these tests will be borne by the Missouri Valley and Blair Railway and Bridge Company; should these tests prove unsatisfactory, they will be charged to the Contractor. The expense of tests does not include the value of the eye-bars.

The Contractor will be required, under a penalty of $150 a day, to have the work completed so that trains can be run across the bridge on November 15th, 1883, and the Contractor will receive a bonus of $100 for each day by which this date may be anticipated.

GEORGE S. MORISON.

November 1st, 1882. *Chief Engineer Missouri Valley & Blair R. & B. Co.*

APPENDIX H.

TESTS AND ANALYSES OF STEEL EYE BARS.

Dimensions.—Inches.			Summary of Results of Mechanical Tests made at Watertown.							Chemical Analyses made at the Pittsburgh Testing Laboratory. Note — Analyses were made of samples from each head					
						Extension.				Decimals of One per Cent					
Length c. to c.	Width.	Thickness.	Elastic Limit. Pounds per Square Inch.	Maximum Load. Pounds per Square Inch.	Reduction of Area. Per cent.	Gauged Length Inches.	Per cent	Modulus of Elasticity.	Remarks.	Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Copper.
172.12	6.52	1.02	34,890	69,250	44.2	120	12 2	30,456,000		0.270 0.270	0.680 0 580	0 041 0.039	0.062 0.065	0 071 0.091	0.030 0.035
180.80	6.52	1.38	33,670	66,700	45.0	120	22.0	28,846,000		0.250 0.250	0.880 0.890	0.042 0.044	0.095 0.080	0.120 0.112	0.085 0 080
180.92	6.52	1.54	34,470	69,920	42.1	120	16.6	29,702,000		0.290 0.300	0.680 0.680	0.055 0.058	0.060 0.043	0.058 0 057	0.060 0.055
264.00	6.52	1.14	32,570	64,740	46.6	200	20.0	29,498,000		0.240 0.240	0.780 0.780	0.044 0 047	0.064 0.075	0.073 0.078	0.030 0.030
295.05	6.03	1.02	24,550	52,390	18.7	...	...	28,089,000	Bar broke in head. Retested.						
300.18	7.02	1.49	24,280	45,270	17.5	200	7.9	28,776,000							
263.96	6.50	1.03	36,270	....	..	.	..	29,940,000	Bar broke in head. Not retested.	0.300 0.300	0.750 0.740	0.042 0.093	0.089 0.070	0.104 0.124	0.033 0.027
263.96	6.48	1.26	37,250	....	.	...	...	30,120,000	Bar broke in head. Not retested.	0.260 0.240	0.830 0.810	0.042 0 060	0.067 0.068	0.207 0 212	0.035 0.037
264.00	6.50	1.26	34,680	64,750	45.9	200	16.5	30,627,000		0.290 0.300	0.730 0 770	0.042 0.047	0.100 0.119	0.082 0.095	0 012 0.016
263.97	6.53	1.40	35,230	64,020	43.9	200	20.7	30,030,000		0.220 0.240	0.760 0.760	0.107 0.046	0.134 0.129	0.107 0.130	0 053 0.053
263.96	6.53	1.39	37,440	70,470	37 9	200	13.1	29,585,000							
264.00	6.52	1.52	32,690	..	..	..	.	30,030,000	Bar not broken						
263.94	6.50	1.02	37,250	67,630	43.1	200	15.0	28,901,000	Bar broke in head. Retested.						
221.88	6.48	0.98	37,480	67,800	33.7	160	15.8	29,880,000		0.300 0.300	0 710 0.620	0.028 0.023	0 092 0.087	0.098 0.089	0.030 0.030
221 60	6.46	0.98	36,650	72,050	38.4	160	13.8	30,270,000	Bar broke in head. Retested.	0.280 0.280	0.730 0.580	0.016 0.019	0.090 0.085	0.097 0.084	0.030 0.030
262.70	6.46	0.98	37,600	68,720	34.1	200	12 3	29,630,000		0.280 0.280	0.650 0.670	0.023 0.014	0.081 0.072	0.092 0.085	0.035 0.030
261.85	6.46	0.96	35,810	65,850	39.2	200	12.0	29,960,000		0 300 0.300	0 640 0.670	0.070 0.011	0 095 0.072	0.093 0 086	0 035 0.035
262.12	6.45	0.97	33,230	64,410	49.5	200	16.4	29,670,000		0 300 0.280	0 640 0.650	0 011 0.018	0.067 0.060	0.087 0.081	0 040 0.040
261.72	6.46	0.97	37,640	68,290	42.4	200	13.9	29,960,000		0.280 0.280	0.690 0.670	0 046 0.011	0.074 0.069	0.074 0 083	0.035 0.030

APPENDIX I.

REPORT OF TESTING COMMITTEE.

The undersigned Civil Engineers present at the opening of the Blair Crossing Bridge, October 27th, 1883, report the following result of tests made under their inspection.

The examination was confined to testing the main spans for deflection and general behavior under a maximum moving load.

For this purpose six engines were furnished by the Sioux City and Pacific Railroad Co., classified as below.

Engine No.	Weight of Engines and Tenders in Lbs.			Length between Couplings.
	Engine	Tender	Total.	Feet.
19	71,450	51,500	122,950	52.1
15	70,450	51,030	121,480	51.6
14	70,450	52,450	122,900	51.6
16	71,450	50,770	122,220	51.85
30	76,000	53,350	129,350	51.8
20	69,100	49,150	118,250	51.5

Total weight of moving load, 737,150 lbs. = 368½ tons. Total length of moving load, 310.45 feet.

The three main spans are each 330 feet in length, c. to c. of end pins, divided into 15 panels, 22 feet each.

They are distinguished by letters A, B, C, beginning from the east side.

Deflections were observed at each panel by means of Y levels stationed on upper and lower ends of Piers II. and III.; but owing to the prevalence of a high wind from the south, and local obstructions at east end of Spans A and B, some irregularity in level readings upon the south trusses of these spans has been involved, indicated by a want of uniformity in deflection curve.

Full records of the observations are given in the following table.

TABLE OF DEFLECTIONS.

Panel Points	Span A.		Span B.		Span C.	
	North Truss.	South Truss.	North Truss.	South Truss.	North Truss.	South Truss.
1	$\frac{7}{16}''$	$\frac{7}{16}''$	$\frac{7}{16}''$	$\frac{7}{16}''$	$\frac{1}{2}''$	$\frac{3}{8}''$
2	$\frac{13}{16}''$	$\frac{11}{16}''$	$\frac{13}{16}''$	$\frac{3}{4}''$	$\frac{13}{16}''$	$\frac{3}{4}''$
3	$1\frac{1}{8}''$	$1\frac{1}{16}''$	$1\frac{1}{16}''$	$1\frac{1}{16}''$	$1\frac{1}{8}''$	$1\frac{1}{8}''$
4	$1\frac{3}{8}''$	$1\frac{3}{8}''$	$1\frac{7}{16}''$	$1\frac{3}{8}''$	$1\frac{7}{16}''$	$1\frac{7}{16}''$
5	$1\frac{1}{2}''$	$1\frac{11}{16}''$	$1\frac{11}{16}''$	$1\frac{9}{16}''$	$1\frac{5}{8}''$	$1\frac{1}{2}''$
6	$1\frac{13}{16}''$	$1\frac{11}{16}''$	$1\frac{13}{16}''$	$1\frac{13}{16}''$	$1\frac{13}{16}''$	$1\frac{13}{16}''$
7	$1\frac{7}{8}''$	$1\frac{7}{8}''$	$1\frac{15}{16}''$	$1\frac{13}{16}''$	$2\frac{1}{16}''$	$2''$
8	$1\frac{15}{16}''$	$1\frac{9}{16}''$	$1\frac{7}{8}''$	$1\frac{7}{8}''$	$1\frac{7}{8}''$	$1\frac{7}{8}''$
9	$1\frac{13}{16}''$	$1\frac{5}{8}''$	$1\frac{15}{16}''$	$2''$	$1\frac{3}{16}''$	$1\frac{3}{4}''$
10	$1\frac{9}{16}''$	$1\frac{9}{16}''$	$1\frac{5}{8}''$	$1\frac{9}{16}''$	$1\frac{5}{8}''$	$1\frac{11}{16}''$
11	$1\frac{7}{16}''$	$1\frac{1}{8}''$	$1\frac{3}{8}''$	$1\frac{3}{8}''$	$1\frac{3}{8}''$	$1\frac{3}{8}''$
12	$1\frac{1}{16}''$	$\frac{1}{2}''$	$1''$	$1\frac{1}{4}''$	$1\frac{1}{16}''$	$1\frac{1}{8}''$
13	$\frac{11}{16}''$	$\frac{1}{4}''$	$\frac{11}{16}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{3}{4}''$
14	$\frac{1}{2}''$	$\frac{3}{4}''$	$\frac{7}{16}''$	$\frac{1}{2}''$	$\frac{7}{16}''$	$\frac{7}{16}''$

The central deflection in all three spans, making allowance for slight imperfections in instrumental work was $1\frac{13}{16}$ inches, and upon the removal of the load the trusses returned to their normal positions. This deflection is equivalent to about $\frac{1}{2000}$ of the span length, which is quite within the limit of rigidity required in structures designed to carry the heaviest traffic.

During the movement of the train over the bridge there was practically no vibration, and all members of the structure appeared to be working in harmony with the general design upon which it was constructed.

Without having made a critical examination of the strain sheets, distribution of material, or workmanship, we are nevertheless fully warranted in bearing testimony to the general excellence of the design; and in expressing the opinion from the results above referred to, and our knowledge of the methods employed by the Chief Engineer, Mr. George S. Morison, in the management of the work, that the Blair Crossing Bridge has been thoroughly well designed, and in execution it is the equal, if not the superior, of any bridge of similar character in the country.

Charles Macdonald,
President Delaware Bridge Co.

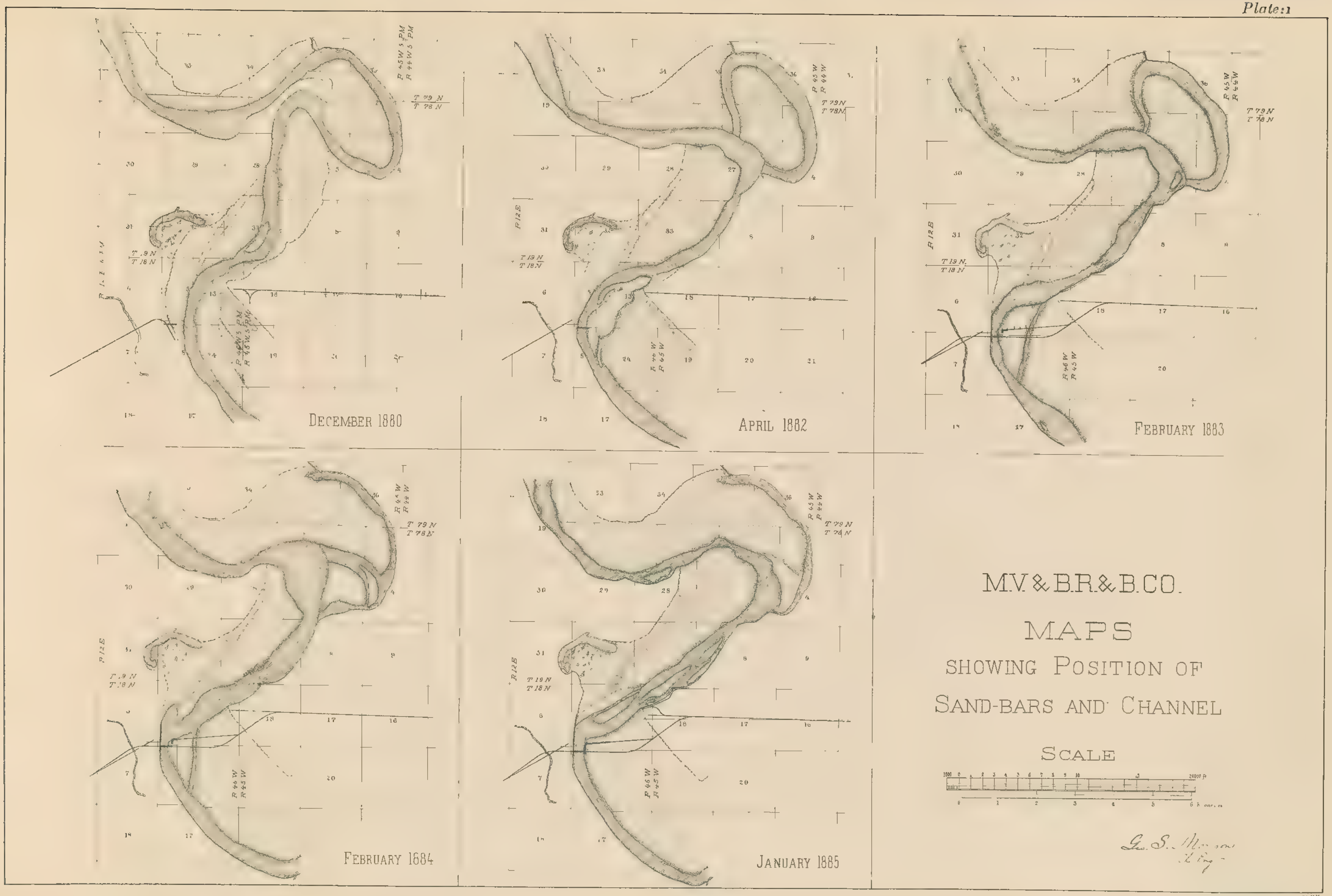
E. H. Johnson,
Chief Engineer C. & N. W. Ry.

R. E. Farnham,
Principal Assistant Engineer C. & N. W. Ry.

J. E. Ainsworth,
Chief Engineer S. C. & P. R. R

Samuel H. Yonge,
Civil Assistant Engineer in charge of Kansas City & Leavenworth Divisions U. S. Imp. Mo. River.

L. E. Cooley,
Chief Civil Assistant Engineer U. S. Imp. Mo. River.



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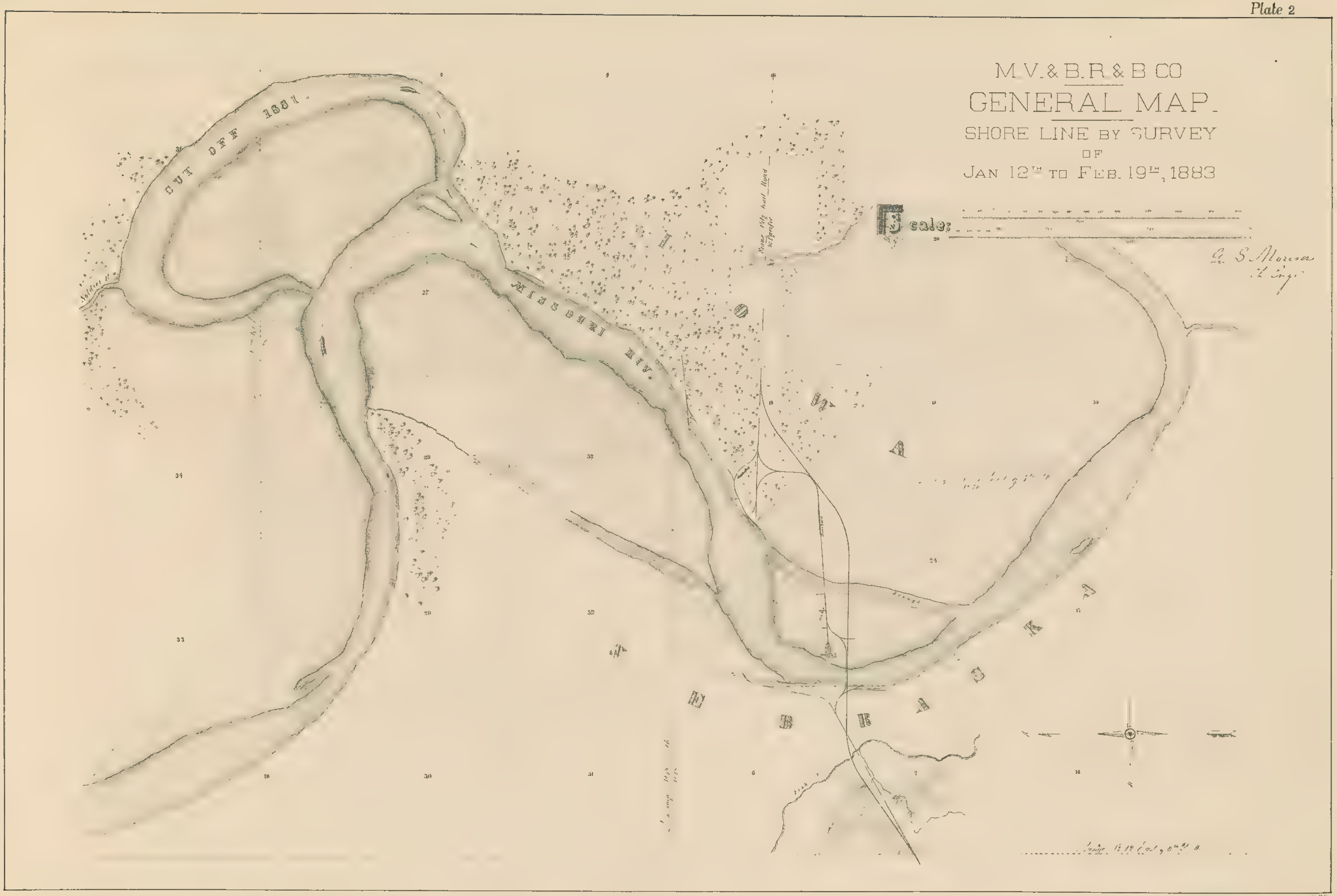
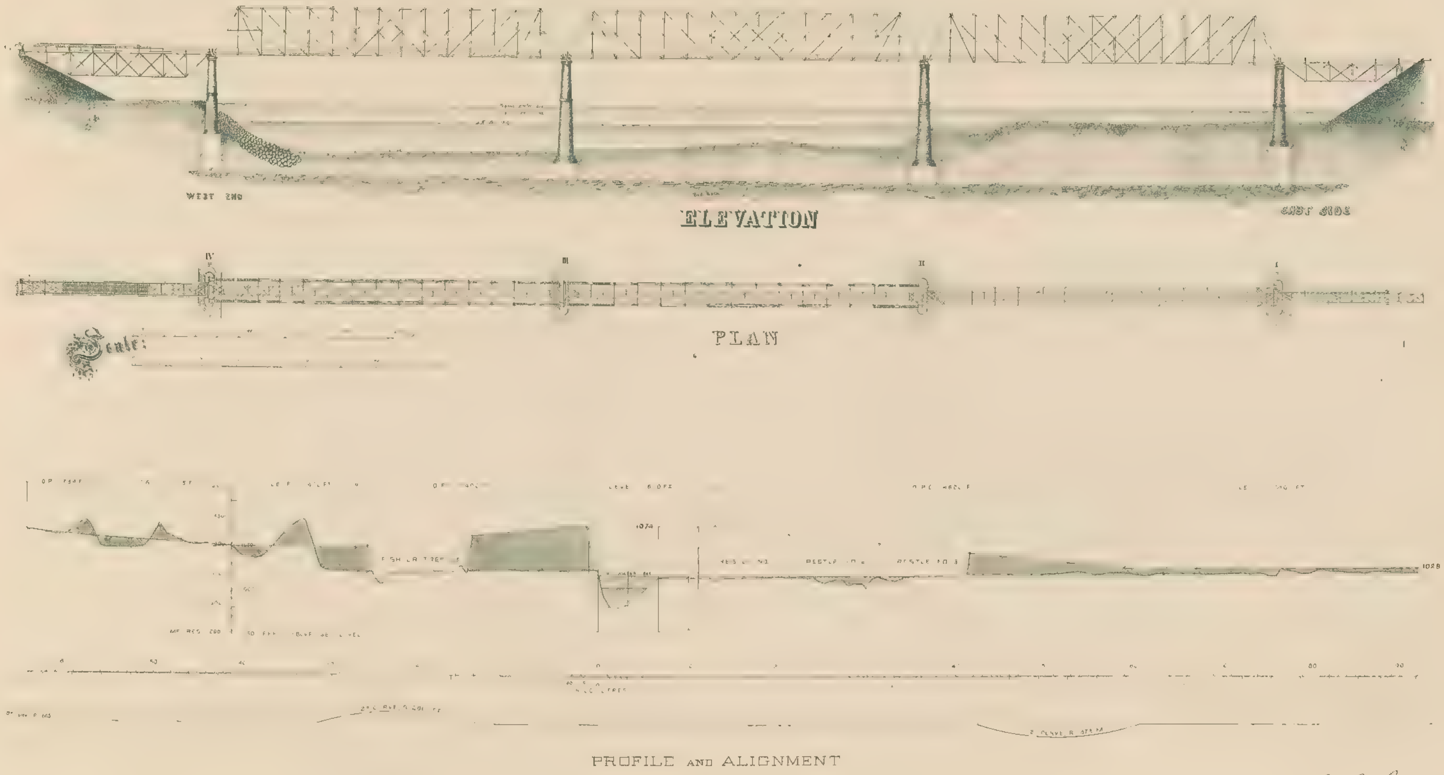


Photo-lith by Robert A Welcke 178 William St N Y

M.V. & B.R. & B.Co.

GENERAL ELEVATION, PLAN & PROFILE



Geo. S. Morison
Ch. Engr.

M.V.& B.R.&.B.CO.

PIERS II & III

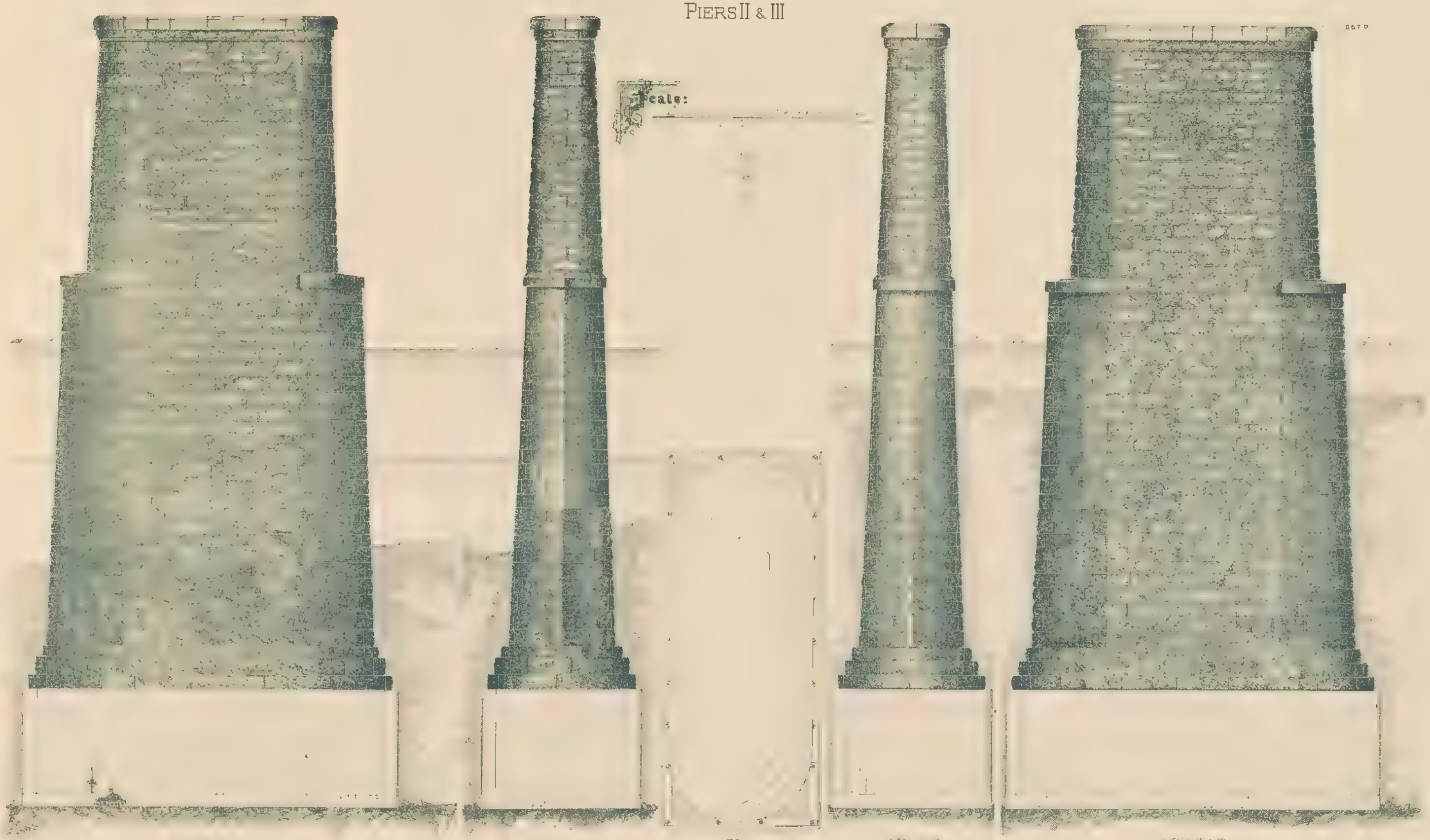
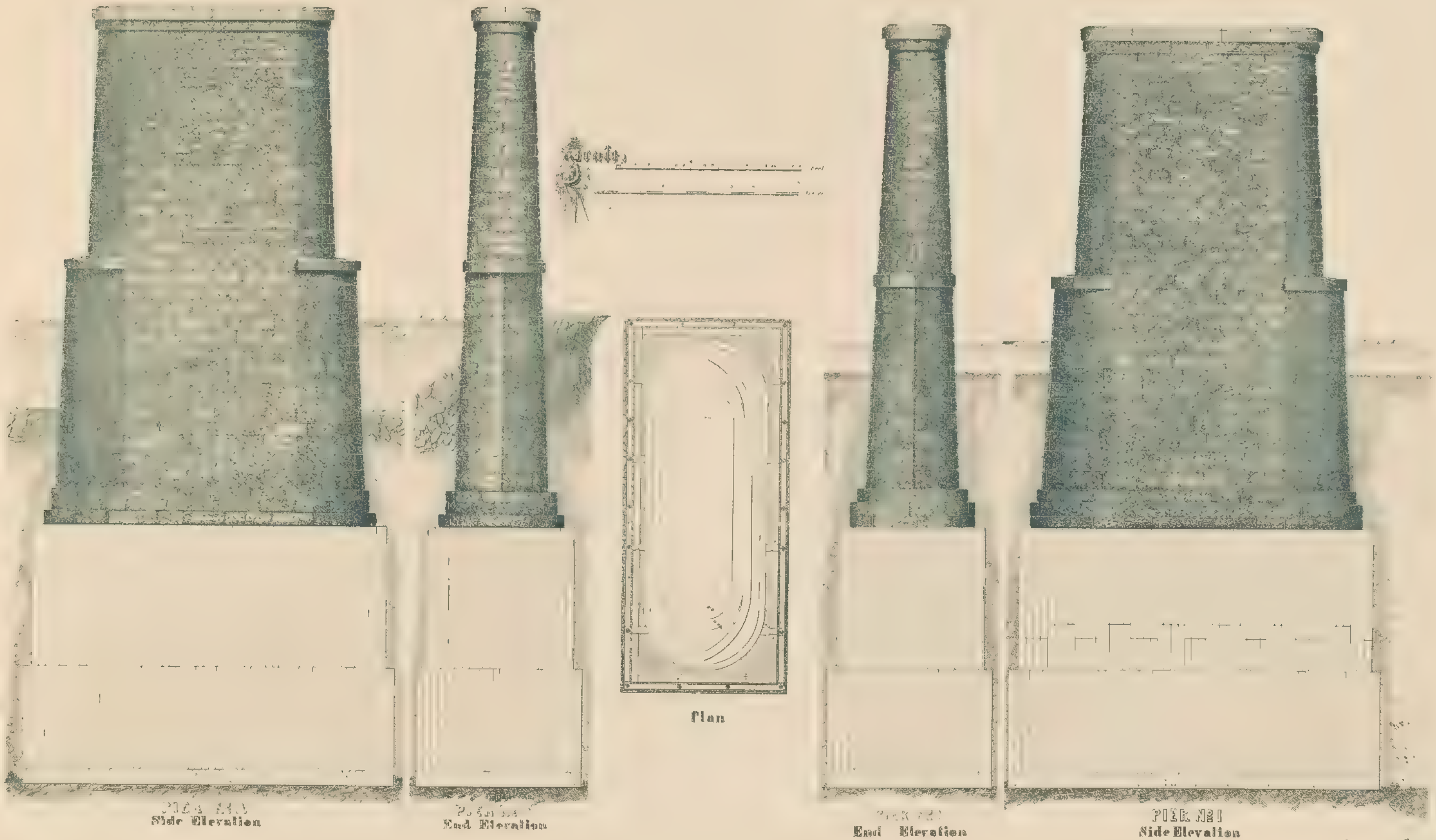


Photo lith. by Robert A Welcke 178 William St N.Y.

M.V. & B.R.& B.CO.

Piers I & IV

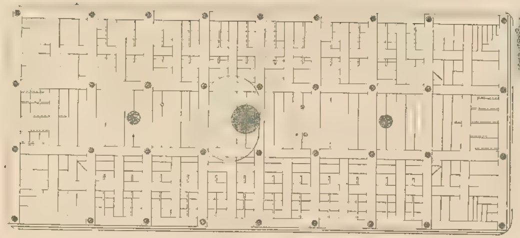


Geo. S. Morison
Ch. Engr.

Photo by Robert A Welcke 78 William st N Y

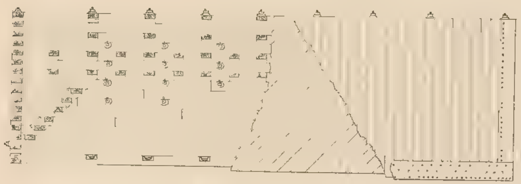
M.V. & B.R. & B. CO.

Scale:

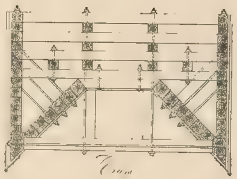


Plan

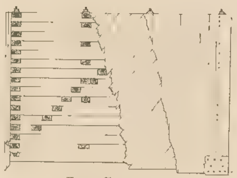
GENERAL PLAN of CAISSON



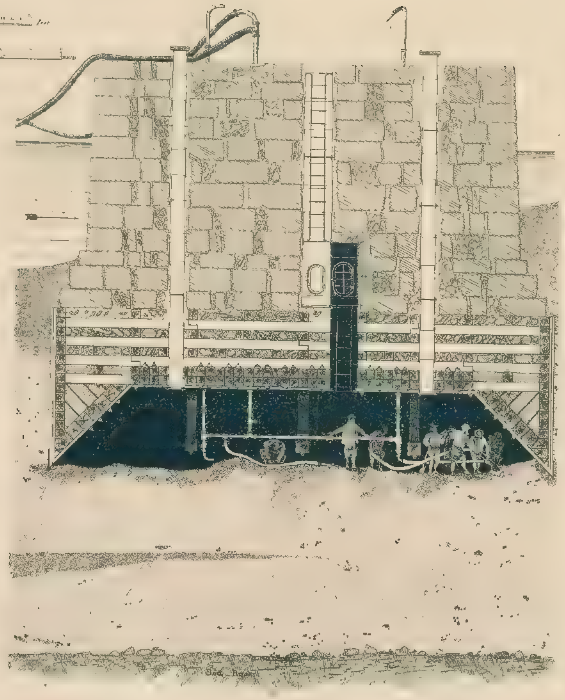
Side Elevation



Cross Section



End Elevation



Longitudinal Section

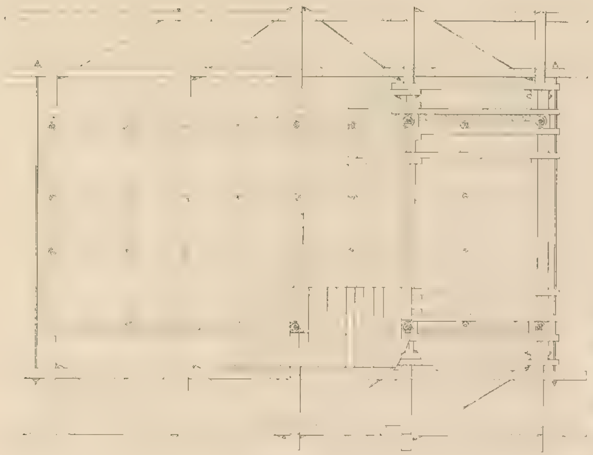
Showing sinking in progress Pier No. III — Jan 25th 1883

Geo. S. Morison
Ch. Engr.

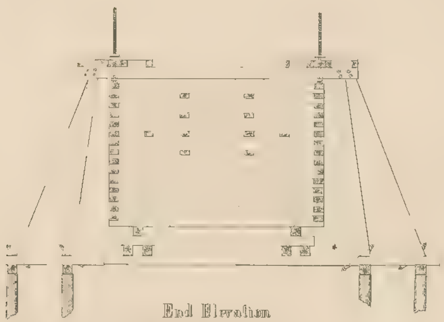
M.V. & B.R. & B. Co.

METHOD OF HANDLING CAISSON OF PIER III

Geo. S. Morison
C. Engr.

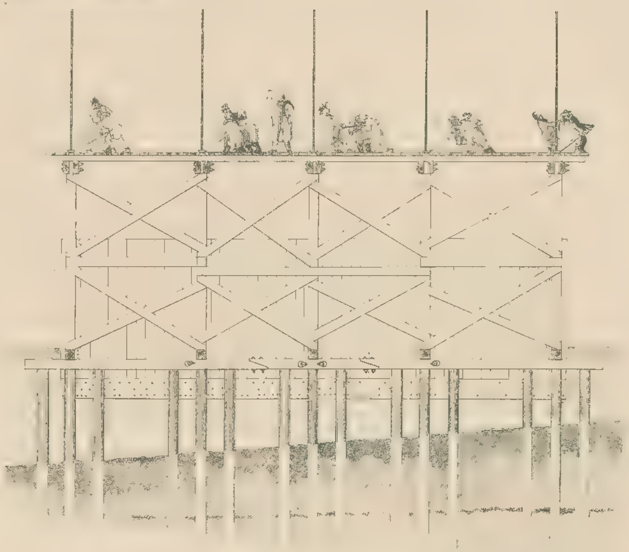


Plan



End Elevation

Caisson in progress of construction



Side Elevation

Photo-lith. by Robert A. Welcke 178 William St N.Y.

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DIAGRAM SHOWING RATE OF PROGRESS IN SINKING CAISSONS

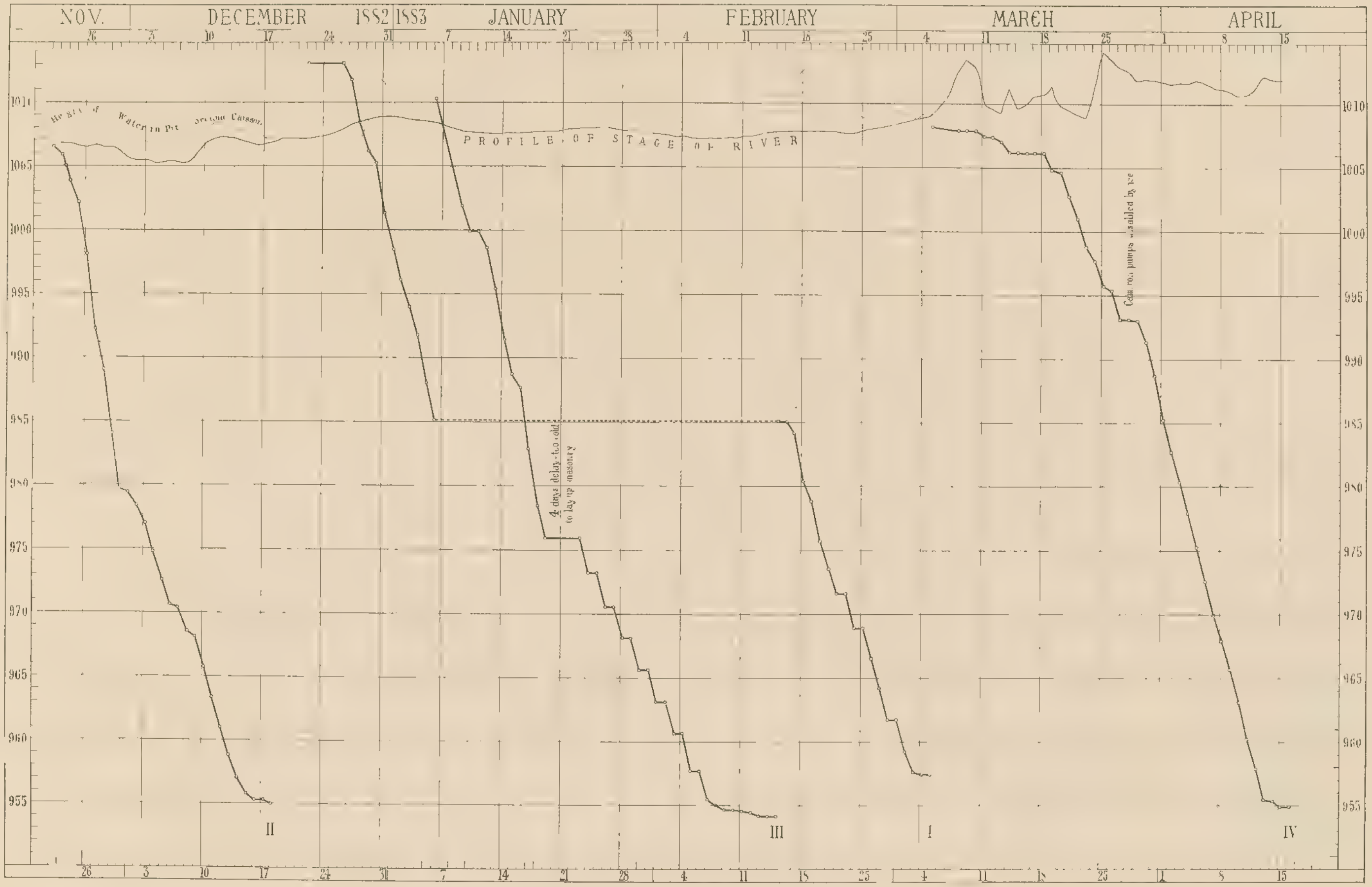
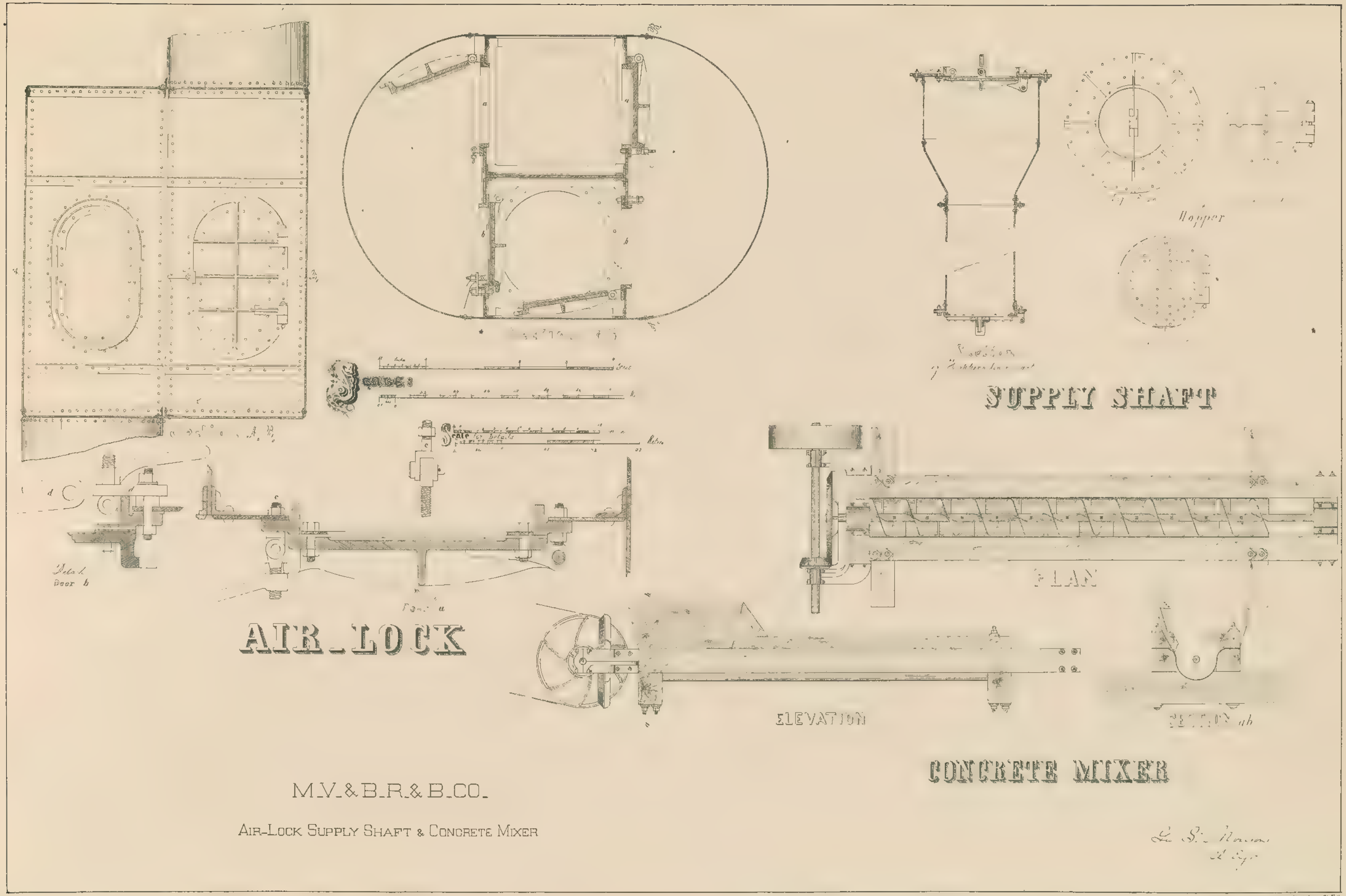


Photo lith. by Robert A. Welcke, 78 William St. N.Y.



AIR_LOCK
SUPPLY SHAFT
Hopper
Scale for details
Detail Door b
PLAN
ELEVATION
CONCRETE MIXER
M.V. & B.R. & B.CO.
Air-Lock Supply Shaft & Concrete Mixer

M. V. & B. R. & B. Co.
RECORD OF WATER STAGE
OF THE
MISSOURI RIVER
NEAR BLAIR, NEB.

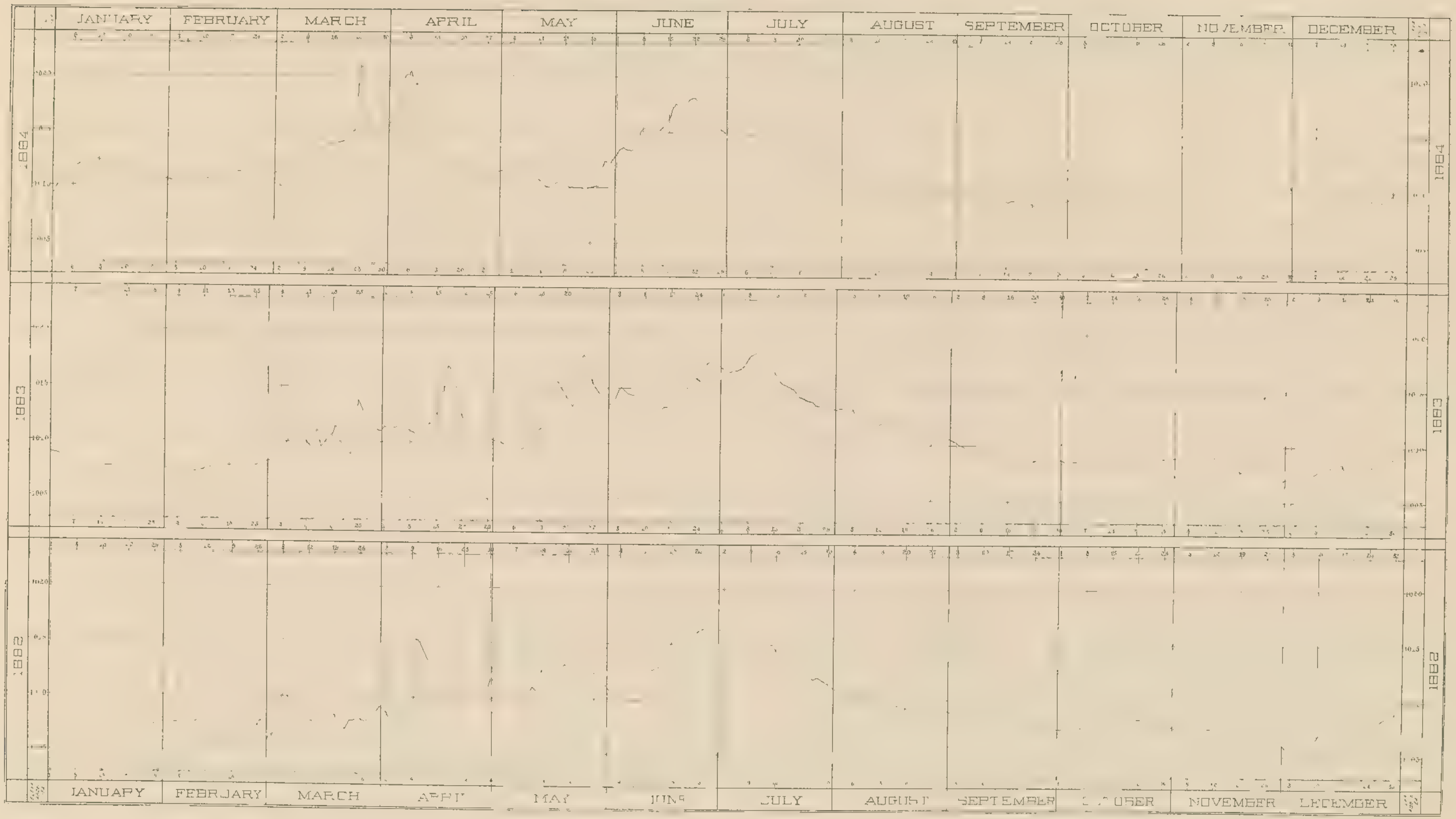
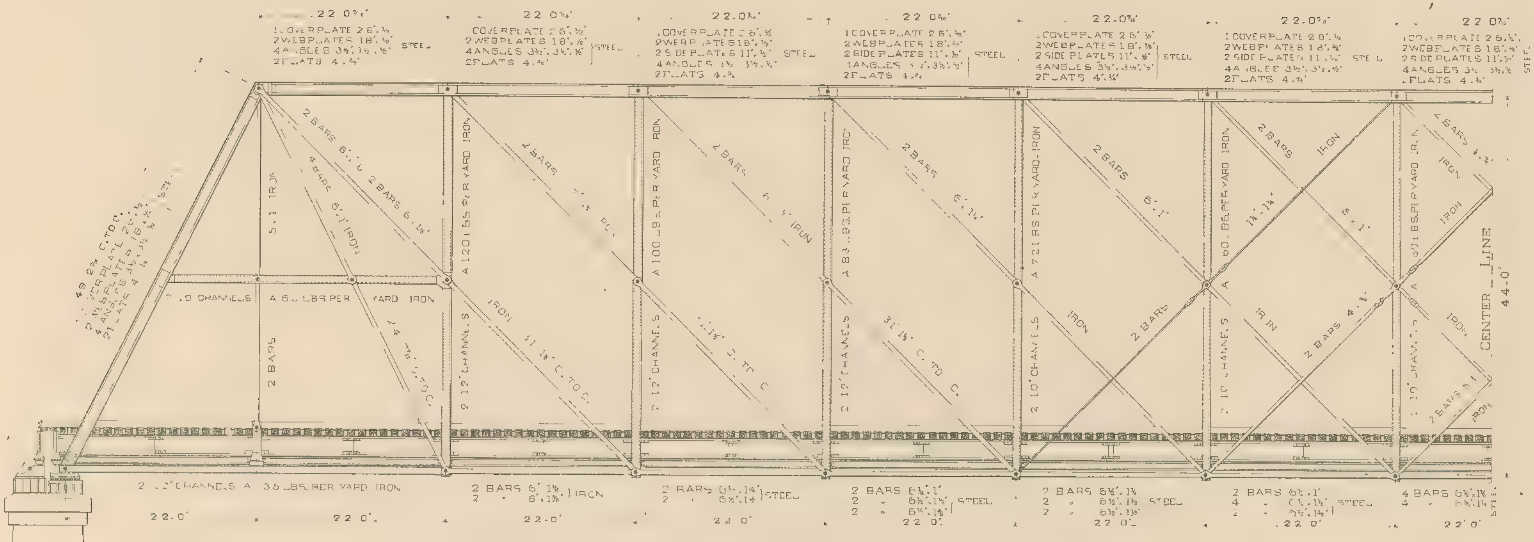


Photo-lith by Robert A Welcke 178 William St N.Y.

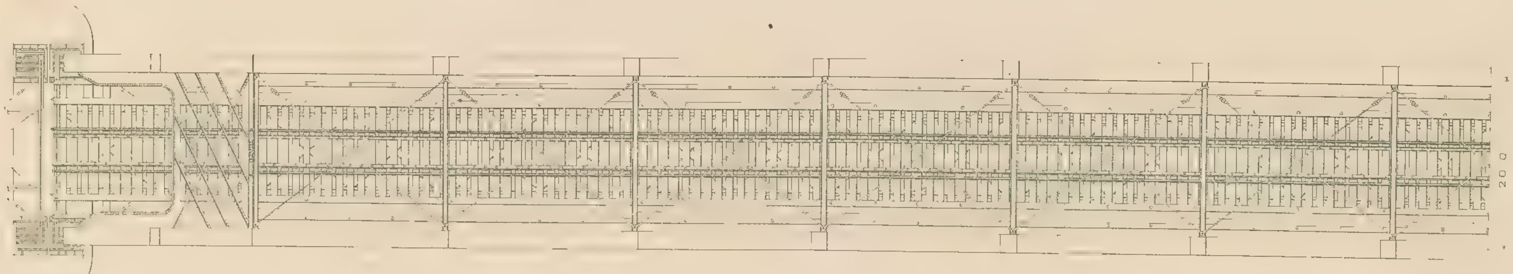
M.V. & B.R. & B.CO.

GENERAL ELEVATION & PLAN OF 330 FT. SPAN

Geo. S. Morison
Ch. Engr



ELEVATION



PLAN

SCALES

M.V. & B. R. & B. CO.

DETAILS OF 330 FT. SPAN

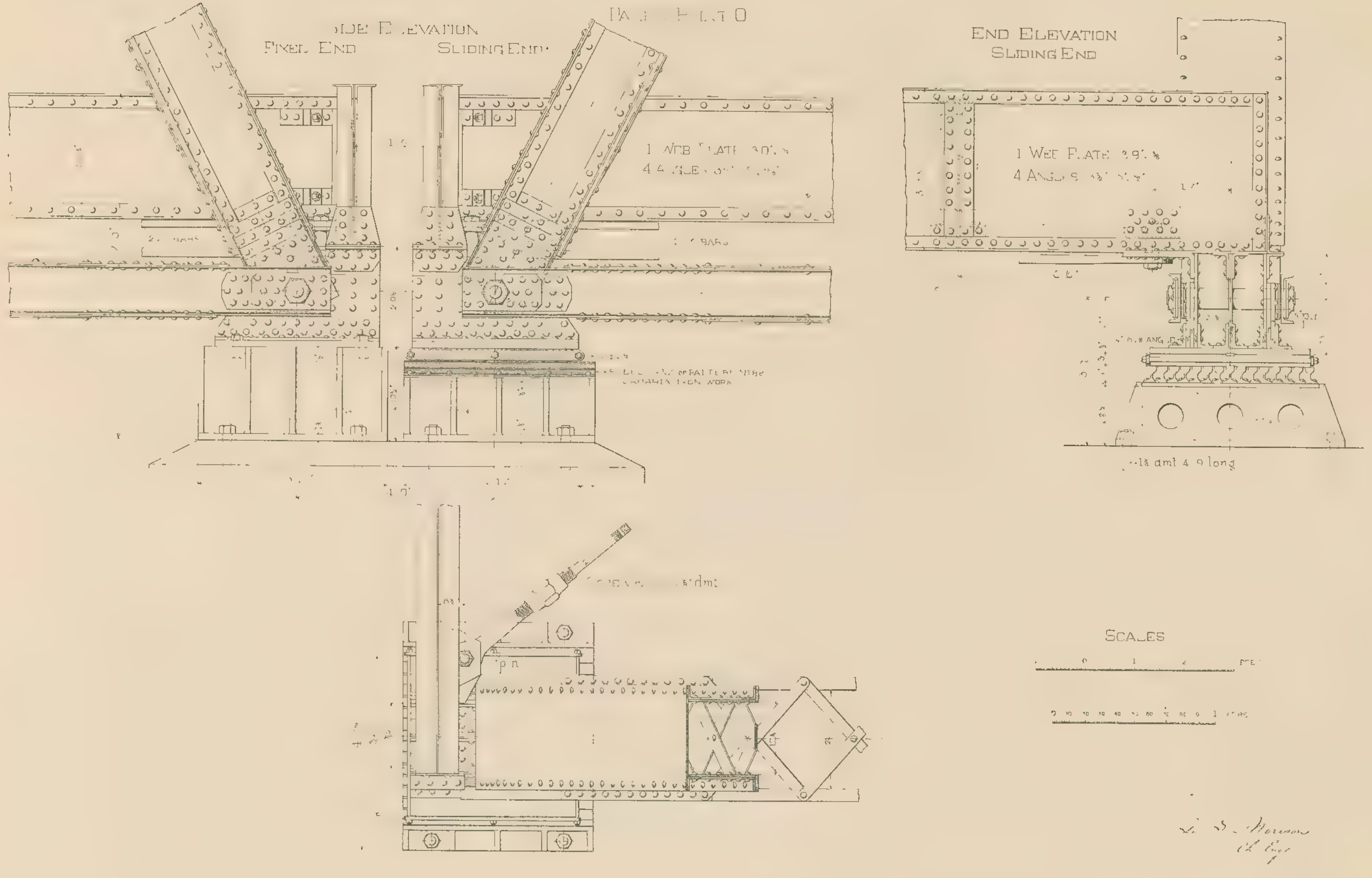
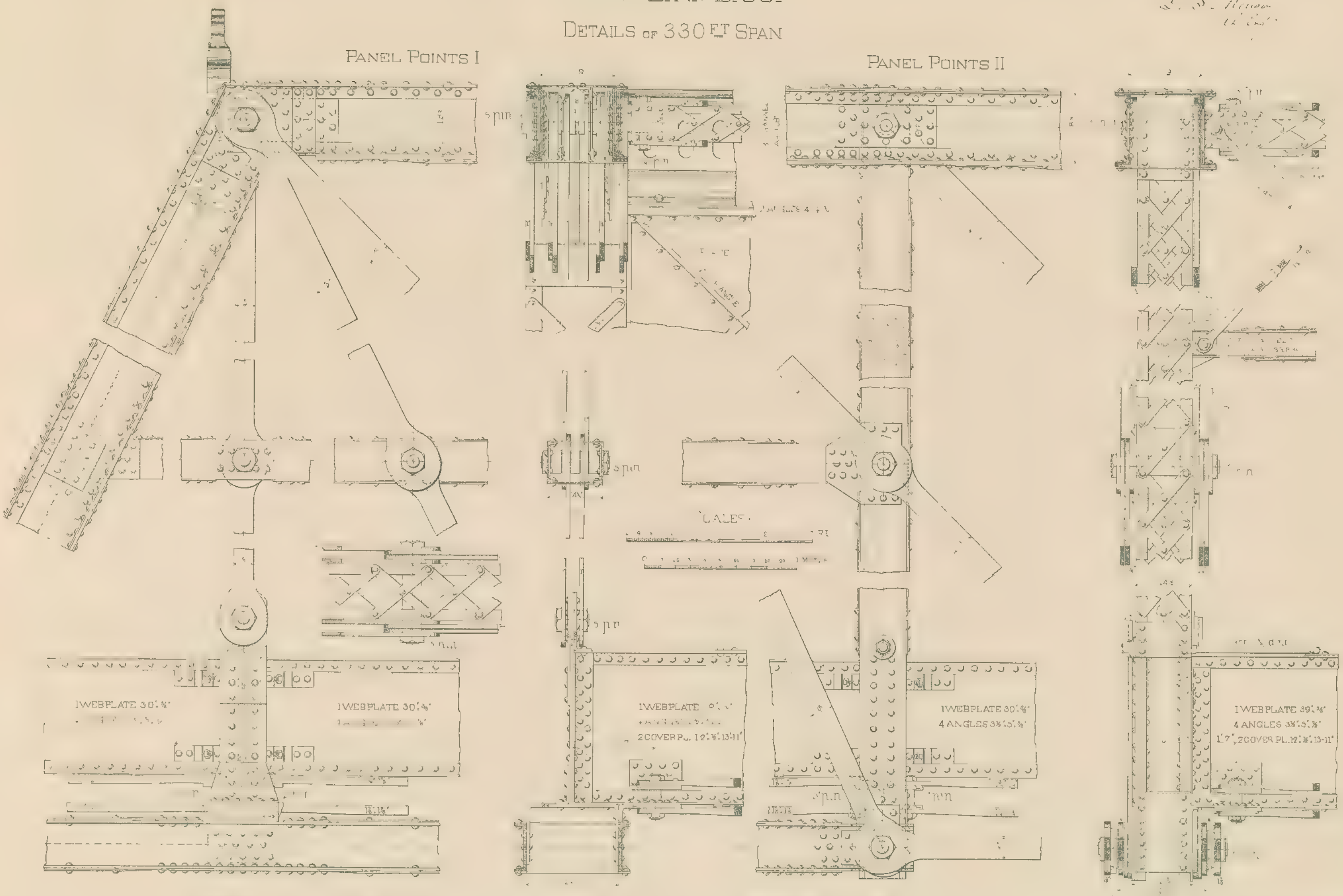


Photo-lith by Robert A Welcke 178 William St N.Y.

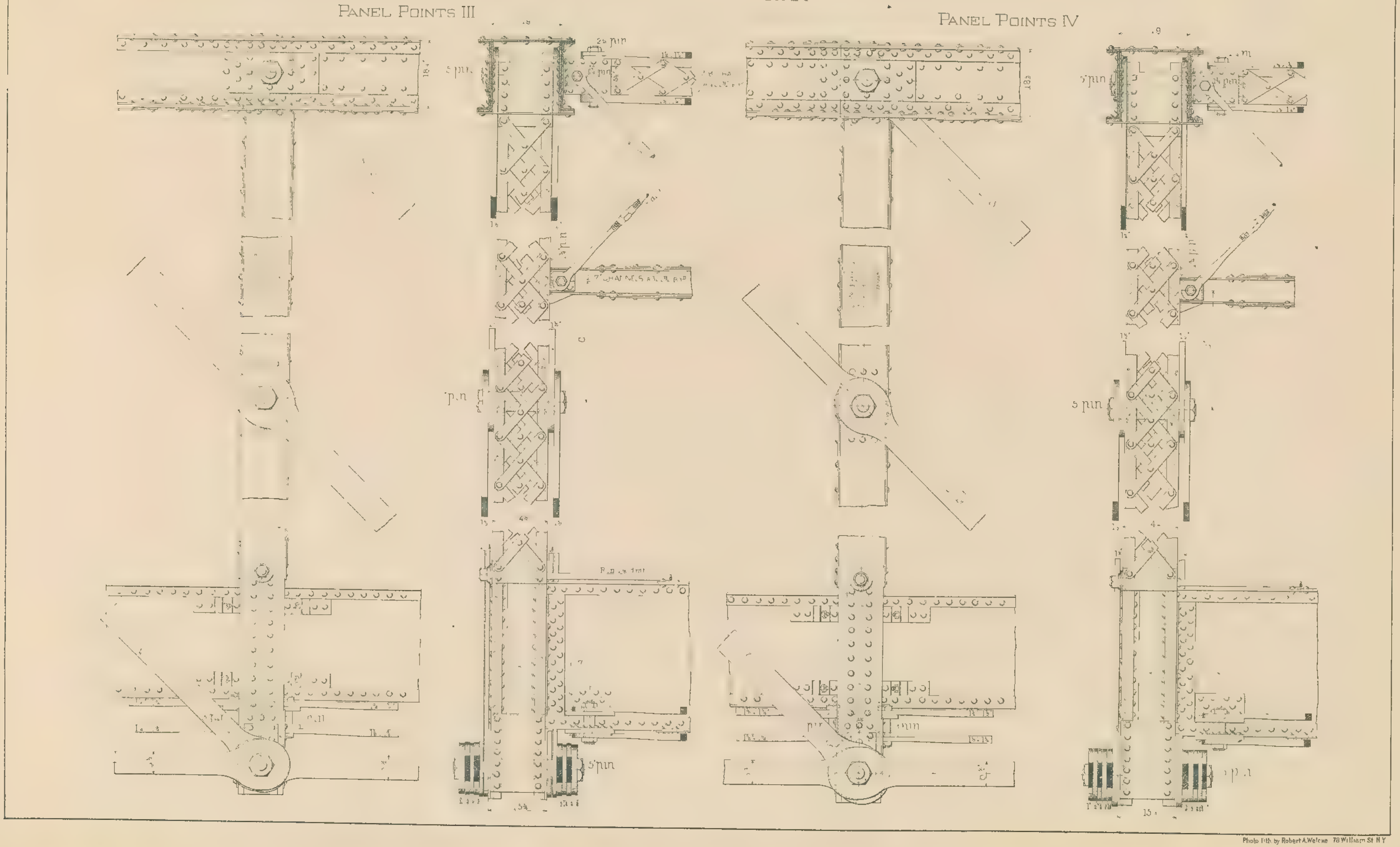
M.V.& B.R.& B.CO.

DETAILS OF 330 FT SPAN



M.V. & B.R. & B. CO.

DETAILS OF 330 FT. SPAN



M.V. & B.R. & B. CO.

Letails of 330 FT Span

G. S. Morison
C. Eng.

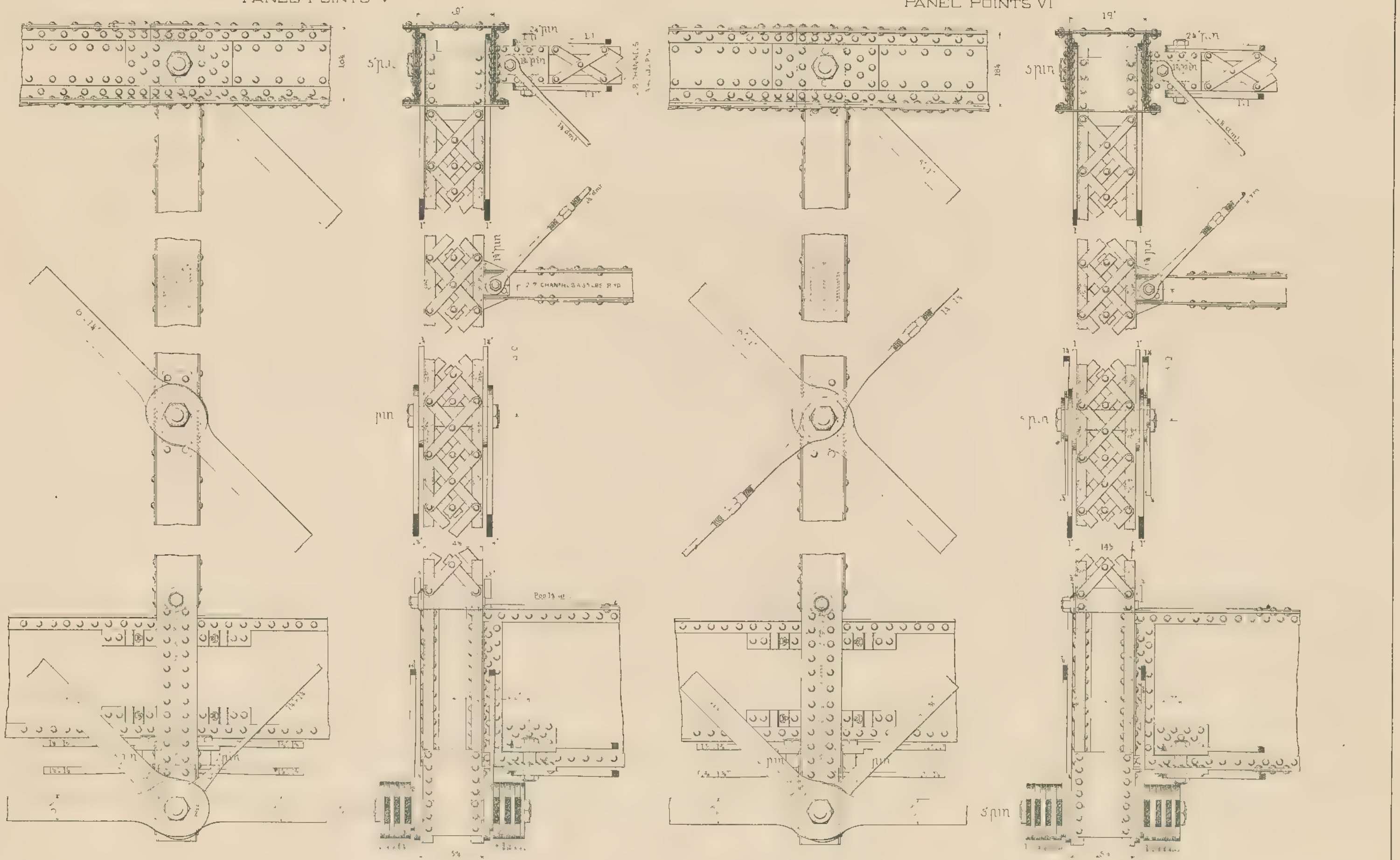


Photo-lith by Robert A. Welcke, 78 William St. N.Y.

M.V.&B.R.&B.CO.

DETAILS OF [illegible] SPAN

PANEL POINTS VII

HALF CROSS [illegible] AT CENTER

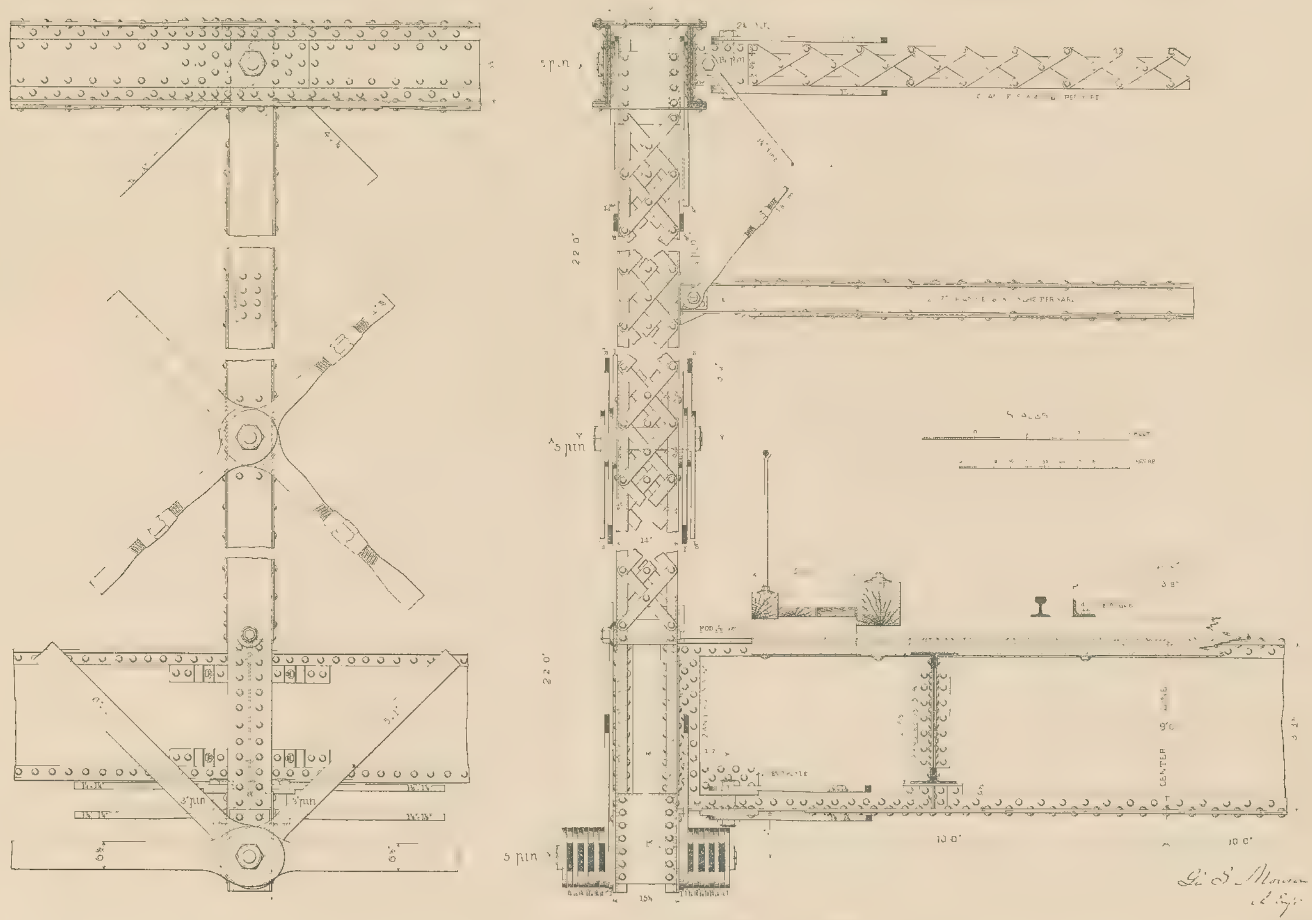


Photo [illegible] by Robert A. Welcke [illegible] N.Y.

M.V.&B.R.&B.CO.

DETAILS OF 176 FT SPAN

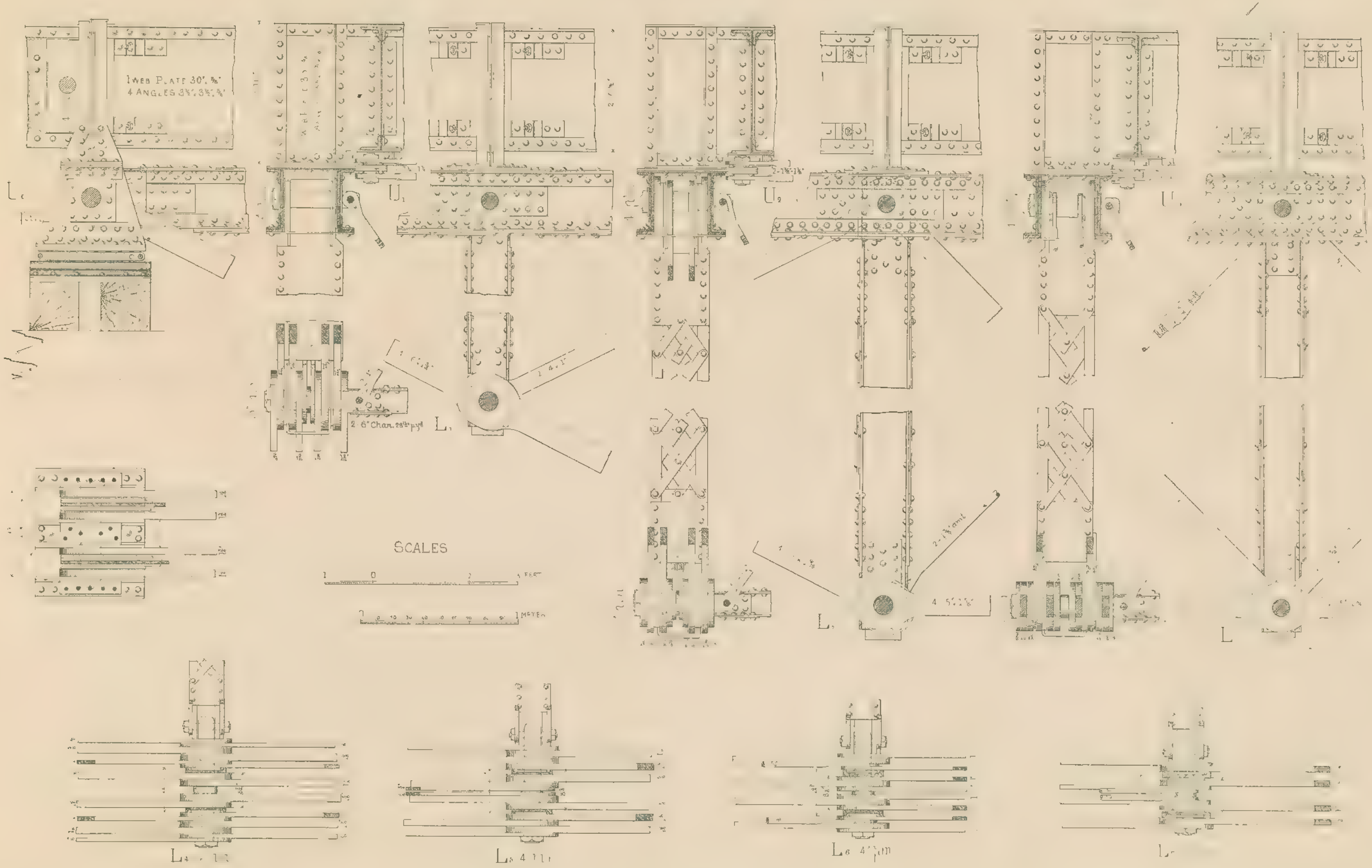


Photo lith by Robert A Welcke 178 William St N.Y.

Plate: 18

M.V. & B. R. R. & B. CO.

DETAILS OF 110 FT SPAN

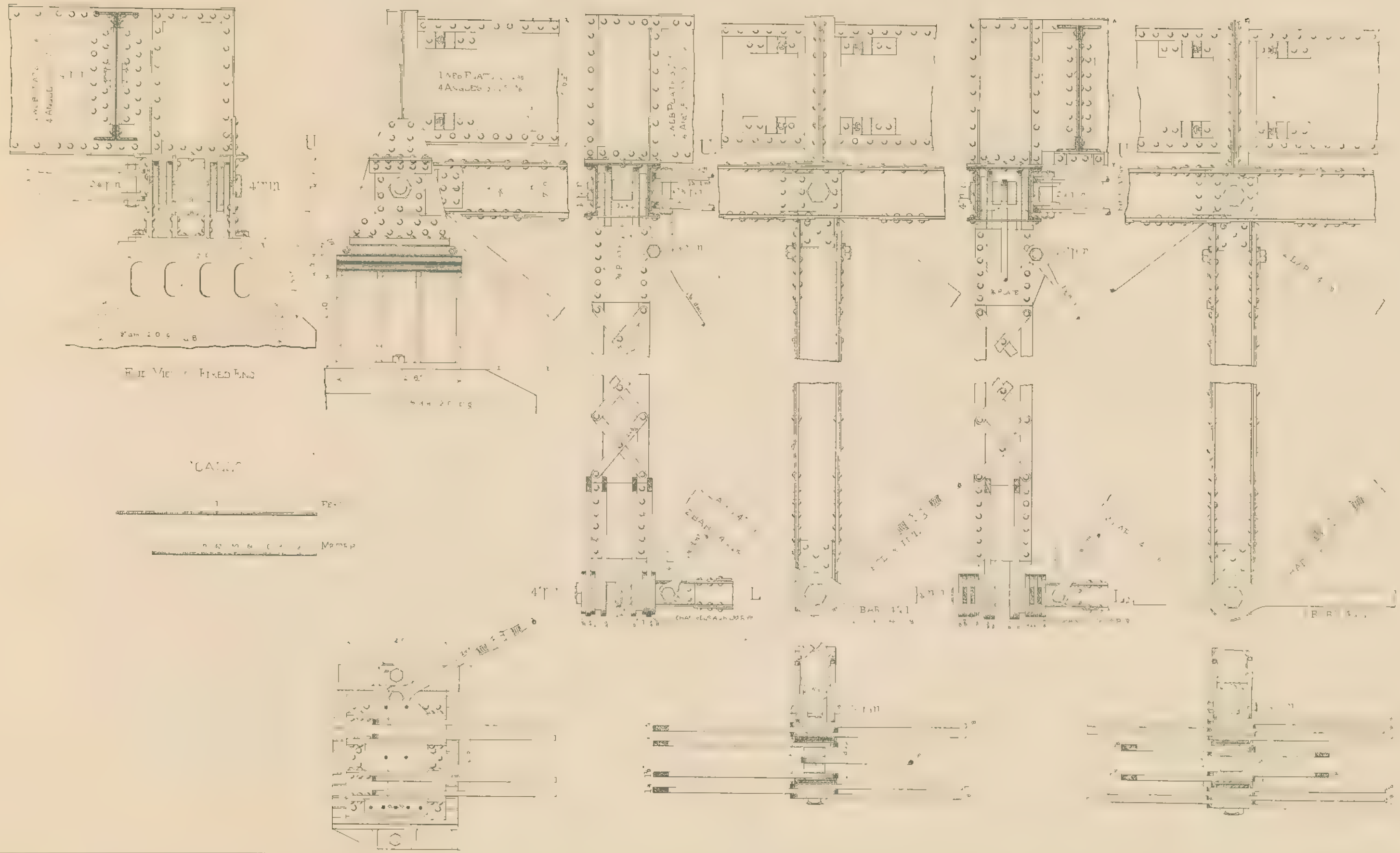


Photo ... by Robert A. Welcke ... N.Y.

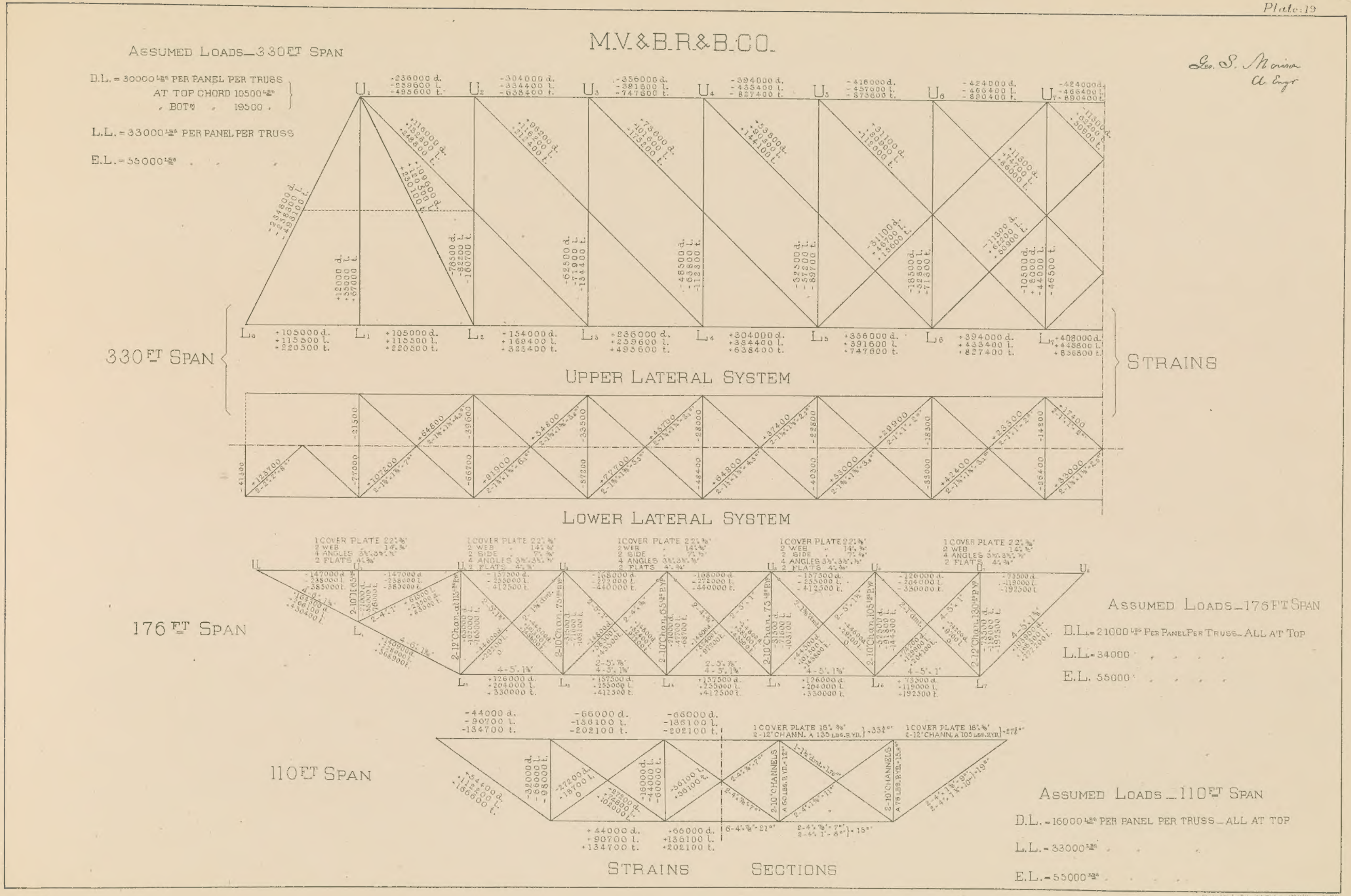


Photo-lith. by Robert A. Welcke 178 William St. N.Y.